Journal of the Society of Arts.

FRIDAY, MAY 18, 1855.

ARTIZANS' VISITS TO THE PARIS EXHIBITION.

A circular has just been addressed to the Mayors of Boroughs and the Superintending Registrars, by the Home Secretary, to the effect that Her Majesty's Government, being desirous of affording facilities to workmen for visiting the Industrial Exhibition in Paris, intend to grant them passports free of the usual fees. Lists of such workmen as wish for passports are to be forwarded from time to time to the Foreign Office, when passports, valid for one month, will be transmitted to the Mayors and Registrars, who have been requested to see that each passport is properly signed.

INSTITUTE BOOK ORDERS.

The existing arrangements in regard to the purchase of books and periodicals by the Institutions in Union at reduced rates have now been in operation 19 months. The experience gained during this period shows that the delays necessarily involved in the execution of the orders at one particular period only in each month have been a source of inconvenience to the Institutions, and have been said, in some instances, to more than counterbalance the benefits derivable from the reductions. It has been found, too, that when the Agent's commission of 5 per cent. on the reduced rates came to be added to the account, the average rate of discount did not exceed 25 per cent., notwithstanding the much higher rates allowed by some publishers.

The Council, being desirous of improving on these arrangements, and if possible of obtaining greater facilities for the Institutions, caused inquiries to be made in the trade, and they have now the satisfaction of stating that a responsible firm are prepared to undertake the whole affair on the following terms:—To supply the orders sent through the Society of Arts from day to day, at a discount of 27½ per cent. off *books*, and 25 per cent. off *periodicals*, except where such periodicals are irregular in price, such as the Quarterlies, in which cases they will charge the *trade price*,—that is, the Institutions will receive the full benefit allowed to the trade.

In future one copy of an order only will be required. This must be sent to the Secretary to the Society, as heretofore, by whom it will be countersigned, and be at once passed on to the agents, with whom the remainder of the transaction will rest. It will then be invoiced, and the Institution will be informed by the Agents of the amount to be remitted. On this being received by them, the order will be immediately executed, the invoice being returned to the Institution receipted.

March Account.

	Full Price. £	s.	d.	Red. Price. £.	s.	d.
Annan, Mechanics' Institute ...	18	0	10	13	8	3
Colchester, Mechanics' Institution	1	18	6	1	9	5
Crieff, Mechanics' Institution ...	10	9	3	7	9	7
Durham, Mechanics' Institute	9	10	0	7	5	4
East Retford, Literary and Scientific Institution	0	19	9	0	15	7
Hants and Wilts Educational Association	1	0	6	0	16	5
Hitchin, Mechanics' Institute ...	7	13	6	5	18	0
Horncastle, Mechanics' Institution	0	12	0	0	9	8
Sevenoaks, Literary and Scientific Institution	4	16	2	3	15	8
Stamford, Institution	3	2	1	2	10	10
Stockton-on-Tees, Mechanics' Institute	5	1	0	3	13	4
Stratton (near Swindon), St. Margaret's Library and Reading Society	1	15	6	1	7	8
	£64	19	1	£48	19	9

Being a saving of £15 19s. 4d., or nearly 25 per cent.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 16, 1855.

The Twenty-Second Ordinary Meeting of the One Hundred and First Session, was held on Wednesday, the 16th inst., the Right Hon. the Earl of Hardwicke in the Chair.

The following Candidates were balloted for and duly elected:—

Bowman, John | Holmes, Herbert Mountford

The following Institution has been taken into Union since the last announcement:—

393. Red Hill, Institute.

On the walls were suspended a collection of Photographic Views of the building in which the Industrial Exhibition was held at Munich last year, presented to her Majesty's Government by the Government of Bavaria, and forwarded by direction of the Earl of Clarendon to the Society.

On the table was exhibited, by Messrs. W. Appleton and Co., a patent bed or mattrass for the army and navy, for travellers and emigrants, and also for use in camp hospitals. It makes a round package, 2 feet long and about 7 inches diameter, and weighs only about 4¾ lbs. When spread open it forms a mattrass 6 feet long by 2 feet broad. The under covering consists of waterproof material, the upper of non-waterproof material. Between the two there are tranverse corrugations, 1¾ inches broad, filled with ground or pulverised cork (a sample of which was shown)

The advantages claimed for this invention are that from the absence of fibre, as in hair, wool, or cotton, the cork will not "mat" or "felt" together in the slightest degree; hence its elasticity is retained to the last. It will not imbibe water or moisture in the same degree as any other material, while the cork acting as a non-conductor, the warmth of the body is retained to a much greater extent than would be the case with other material of the same bulk and lightness; and from the nature of its manufacture, partially in the state of charcoal, it has sanitary and purifying qualities peculiarly its own. No insect can exist in it, and if it becomes damp it does not heat, ferment, or rot, as wool or straw when moist. From the buoyancy of cork the beds might, under certain circumstances, be combined, and be useful to the army for pontoons, and to the navy as floats to support rafts, or even overladen boats. Singly they will sustain the heaviest man in the water.

The Noble CHAIRMAN, after expressing his high sense of the honour conferred upon him by the invitation of the Council of the Society to preside on this occasion, and having referred to the novelty of that position as regarded himself, said he had been induced to take the chair at this time from the circumstance of that description of science which they were this evening called upon to listen to being connected with a profession in which he had been brought up, and which he ardently loved. It was also at a period of time when the science of this country must and ought to be directed with great perspicuity and attention to that branch which they would this evening be particularly called upon to attend to; and although it was a branch of science which, he might say, was better understood in this country than in any other, yet much required to be done to mature that branch in such a manner as to make it thoroughly and cheaply available to all the purposes which they desired it to attain. He had also felt that he might not only receive great enjoyment from a discussion of this kind, but that he should assuredly receive a great amount of information himself by having an opportunity of attending this meeting; and he, moreover, felt that this Society might connect itself at this period very importantly with the various branches of science that are in embryo in this country, but which did not receive from time to time that consideration and attention which they ought to receive. They did not receive that attention and consideration from certain portions of the public, and they required to be pressed upon the public by the earnest and ingenious minds of those who contemplated any experiments or any novelties that might fill their breasts. When speaking of the government of this country, he spoke of it as a machine for the interests of the country at large, bearing upon all those important points which regulate not only the government of the country, but which ought to tend to draw forth at this period all the abilities, all the scientific knowledge, and all the circumstances which might lead to the great object which they had every one of them in view. He would assume that the government of the country, so taken up as it was and pressed by the arduous duties it had to perform, stood in perfect horror and dread at all times of novelty. He had had that strongly impressed upon his mind, and it was one of those points which had induced him to appear before them this evening and to presume to take the chair, and which had led him also into the belief that he might, perhaps, be able to throw out some point or some view which they might take up and enforce in some manner that might lead to useful purposes and to great ends. That there exists an enormous degree of mental power in this country no one could doubt—and also that there exists an enormous amount of education that had raised that power to a great extent; but when that power was brought before the great authorities of the country—when anything in the shape of novelty was introduced, it was received with coldness and dissatisfaction, and no man had the slightest chance before the government authorities of the country of having any great experiment or any great subject he might have imagined brought to a fair consideration. If he stated that which was wrong, it was owing to a misconception of the case; but he had known so many instances himself of the bearing down of great aspirations in the minds of men who had thought and reflected on subjects in reference to great and scientific attainments and great and scientific ends—who had met with so much coldness, that they had been unable to carry on the pursuit of science in the direction they wished, and from their own position in life had been unable to push before the public the ends they had in view—that they had not known where to look for assistance and support. This country was now at war with a great power, and he thought it likely, from what he had seen and heard before, that the government was pressed very much at this time by a number of people who had notions that they could perform all sorts of wonderful deeds, and by which, if they could only get themselves listened to, they could not only take Sebastopol and destroy Cronstadt, but do a hundred other things which would astonish the world and attain the great ends which would satisfy their own honest ambition. But under the circumstances of the case they were not much attended to, and they were obliged to return to their homes, and they sought out some prominent member of parliament, or some other man whom they thought in a position of eminence in the country whom they would beg to look at their plans and give his support to them—he himself, it might be, being unable to say more than that he was obliged, but that he was unable to give them any assistance whatever. He held that there never was a time when among the duties which a great and scientific body might undertake or at least reflect upon, it was of more importance that that question might be met, for he held it to be one of great and serious consequence. He knew, and they all knew, doubtless, if they wished for illustrations of what he had been saying, examples which daily occurred. There was no sort of difficulty whatever in bringing before the public a series of cases of disappointed hopes. He knew a case, without mentioning names, and the public knew it very well, as an illustration of this sort of thing, wherein the government authorities connected with that branch of the profession he was about to mention, thought it right to hand over to a banker in London a sum of money for the purpose of relieving themselves from those duties which they ought to have performed. There was a point of science to be considered, for the invention was claimed by many persons. The individual alluded to was a banker; he was no judge, and he gave the money in a way to raise objections to the mode in which he had disposed of it, and in such a way as was considered on the part of some to be an act of injustice, and led people to apply to a court of justice for the purpose of getting what they considered their right. If there had existed in this country a body of men—a board of scientific individuals, qualified to have taken that case into consideration, and to have given judgment upon it, no doubt justice would have been satisfied, and whether right or wrong in their judgment, reasons would have been given why they so judged, and the public and the individuals themselves might have been satisfied. They had before them, amongst the many plans which existed for various things, an exhibition which, he ventured to say, was a disgrace to the science of this country, and displayed the greatest want of scientific knowledge that ever took place in this country, or perhaps in any country. He alluded to the construction of certain floating bodies, which were to carry death and destruction against the enemy, but which it might be presumptuous in him to say would never do any thing of the sort. By good chance they might take them

across the ocean; but he would venture to say this—if the science of this country had been permitted to deal with the principle that a floating body was to be constructed impervious to shot and shells, that if that principle had been placed in the hands of scientific men in this country, and they had been asked to produce that description of floating body,—he would answer for it this country would have given such a floating body as would perfectly achieve, as far as the floating power went, and the means of being conducted across the ocean—that this country could have given such a body perfect of its kind, and beyond doubt fitted for the proposal named. Whether it would maintain the principle started with, that of resisting shot, was a question which he did not think anything but experiment could deal with. He did not think putting a plate of iron 4½ inches thick upon a raised wall of timber would by any means give the result anticipated, and unless it was tested by placing the vessel within the proper range of shot and shell, the experiment which had been made would afford no criterion of what would be the result under other circumstances. That was another reason why he esteemed it a privilege to occupy the chair of this meeting, if by anything he might say to those who might be inventors—men of inventive genius, offering themselves to the public, and having the Government backs turned upon them on every occasion—an opportunity might be gained by some description of machinery, which, if the Government would not create, this Society, or the men who act in it, might be disposed to aid, for the purpose of giving an opportunity of having before them the inventors and considering their inventions. He knew no more patriotic act at this time, none which would call down more affection on the part of genius and science, than the affording an opportunity to men of genius to lay before the public what they had thought and designed. There was no doubt, in that case, they would be overborne by an enormous quantity of rubbish—no doubt an enormous quantity of dross would fall from the metal, but he believed they would find that in the creations of the human mind, which was an emanation from the Great Creator himself, and was in the first instance not to be taught, for genius existed only through the Almighty power—that that genius would have an opportunity of being brought to light which in this country it had not at this moment. He could mention many other instances—some good, and some, perhaps, worth nothing at all—but he mentioned this circumstance as a reason why, independent of the honour conferred upon him of taking the chair on this occasion, as a reason why he rejoiced in having an opportunity of meeting any body of scientific men, if he succeeded in turning their minds to what he conceived would give an enormous satisfaction to the public at large. In the public writings of the day they were accustomed to see such expostulations as these—"Why is this man not listened to, and why is it not proved what that man can perform? Why are these people not permitted to have their plans examined and considered, that we might know, at least, whether millions of money might not be saved from the public pocket?" He was convinced that if some body, such as he had mentioned, had been in existence, they would never have had half the trouble they had with regard to the late Captain Warner. He was convinced that was a contest carried on for a long period of time, which, by the pertinacity of the public, and of a most proper character, was constantly pressed upon the public notice both in and out of Parliament, and in which the public always felt themselves disappointed. The Government thought they had to deal with a case which was impracticable, but the secrets of the case were never brought to light, the public were never satisfied, and the man passed to his grave. If he had lived in these days it would have been a source of trouble to the public and to the Government as to whether Captain Warner would go to defend Sebastopol, or whether we should give him what he once asked of him (the chairman) £400,000 for an invention which he would not disclose. This, he was aware, was perfectly foreign to the subject of the evening, but he had ventured to say thus much, for the reason that a chairman of a meeting like this must have some peg on which to hang some sort of a speech, or else he would be looked upon as unfit to take any chair, and therefore he had said that which had risen uppermost in his mind—foreign to the subject of the evening, but, nevertheless, in introducing himself to the meeting, he felt it was necessary to utter some few words to some purpose, and having done so, he would now proceed to what was more immediately the business of the evening. This being the first occasion of his appearance before this Society he needed some introduction, but the same was not to be said of his friend who sat on his left (Mr. Atherton). It was fortunate, in his estimation, that her Majesty's Government in these times had been able to obtain the services of that gentleman; in a time in which he did not know whether he could exactly say that steam was in its infancy, but at a time when steam power having obtained a certain standard in the country, there was wanted some men connected with the science of the country who could ascertain and define its capabilities. If he might use the simile, it was like a fine horse, whose paces were well known, but whose paces from its great spirit could not be properly regulated. They wanted some one who had turned his attention to these paces, and to the weights which the horse would carry, to put this subject before them. The subject to be submitted by Mr. Atherton appeared to him to be one more wanting to be considered than almost any other, a subject, it appeared to, him at this moment, if considered and brought into a proper focus, and into a properly tabulated and graduated form, which would render more service in point of revenue to the state, in point of revenue to the merchant, in point of fitting to the ship, than any other point which had been considered in reference to steam power. If from the meeting to-night should emanate a system which might be secured and fastened upon the maritime power of this country, then indeed should he glory in having been their chairman. If from the reading of this paper should emanate a system of classification for calculating the tonnage and power of steam ships, and also with regard to the assimilation of the power to the tonnage, if that point should be gained, dating from the period when this paper was read, and that he had the honour of sitting in the chair, then should he consider those amongst the most usefully spent hours of his life. He would leave merchant steamers out of the question, because they being in the hands of private individuals each was competent to exercise his own method of building, fitting, and equipping his own ship; but it would be later, if ever, that they arrived at that description of fashion which governed the ladies of this country, and which was more powerful in its influences than any law of the land. If the same fashion existed with regard to the fittings of the steam engine, they would give more money to the pockets of the merchants, and more facilities for making all voyages in all countries than by any other single act they could perform. The British navy, propelled by the power of canvas and the wind, immediately classified every sail and spar used for the propulsion of her floating bodies. She also classified her cannon, and everything else in reference to her ships of war, but upon the introduction of steam power into our navy the whole system was capsized; there was neither classification nor system. If a ship was built by a sudden fancy of the First Lord of the Admiralty, or was fitted with a set of engines which the first naval lord imagined to be fit, and some engineer came in and said, "I have got a wonderful invention. I'll drive your ship without steam. I'll do it with heated air alone"—to say not a word about the cylinders being burnt out—£60,000 or £100,000 was laid out, and the thing was done. So with the fittings of the ships and the engines. It was in their power to have every ship fitted with different engines—of different dimensions and power, and if an accident happened to any one of them, it might be a great difficulty to

replace the defaulting portion of the machinery through the mould perhaps having been lost or destroyed. But if from this day they should lay the foundation of any system of classification, which it was high time was done, then they might hope to have the navy as perfect as it could be made. They were that evening called upon to listen to the reading of a paper of very great importance, which, in his opinion, would lay the foundation of the very point that he had endeavoured to urge. They were called upon to attend to a subject whereby the capabilities of steam-ships for sea transport could be as correctly estimated as were the capabilities of the locomotive for land transport; that would be a near approach to laying down an entire system for that service, and they might then determine some standard rule whereby they might assign some definite data for the trial of the vessel if such facts could be actually substantiated. Those were the points that they would be called upon to discuss, and he had only now to apologise for having, as an unscientific man, and as a man with no pretensions to the attainments of the gentlemen he saw around him, but merely as belonging to a profession which had in it some assimilation, and as connected with the great services of the country, for having ventured most humbly to take the chair at this meeting.

The Paper read was

THE CAPABILITY FOR MERCANTILE TRANSPORT SERVICE OF STEAM SHIPS, WITH REFERENCE TO THE MUTUAL RELATIONS OF THEIR TONNAGE, DISPLACEMENT, ENGINE POWER, STEAMING SPEED, DISTANCE TO BE RUN WITHOUT RE-COALING, TONS WEIGHT OF CARGO, AND THE EXPENSE INCURRED PER TON OF CARGO CONVEYED.

By Charles Atherton, M. Inst. C.E., Chief Engineer of H.M. Dockyard, Woolwich.

The object of the following exposition on steam-shipping is to suggest and exemplify some definite process of investigation and arithmetical deduction whereby the capabilities for sea transport service of steam-ships may be as correctly estimated as is the capability for land transport service of the railway locomotive engine. Railway capability has already been reduced to a definite process of calculation, while steam-ship capability has never yet been subjected to arithmetical deduction, simply because the very terms "tonnage" and "horse-power," by which the elementary details of steam-ship service are designated, are absolutely indefinite. No legislative enactment has hitherto defined the standard unit of quantity that is meant by the tonnage of a ship, as denoting the measure of a ship's capability for transport service, either as respects measurement or weight, or what is meant by "nominal horse-power" as the standard unit of the measure of the amount of force which a marine engine may be legally required to be capable of exerting. Nevertheless, ships' *tonnage* and marine-engine *horse-power* are made the nominal base of mercantile pecuniary contracts to the extent of millions per annum. For example, in the Government transport service for the past year (1854), the amount of shipping employed has been designated as about 210,000 tons tonnage and 26,000 horse-power, involving pecuniary contracts based on the indefinite terms *tonnage* and *horse-power* to the amount of £3,000,000 sterling. In fact, it may be plainly asserted that a contract for the building or hireing of ships based simply on the nominal tonnage of the ship and the nominal horse-power of the engines binds the contracting parties as to the sum of money that is to be paid, without affording any definite or specific guarantee whatever as to the amount of capability for service that the vessels so purchased or hired will afford.

Such are the circumstances under which, in continuation of the public efforts that I have made since 1850, by publication and otherwise, to expose the anomalies of steam shipping, I now respectfully call the attention of the Society of Arts to the subject of the capability for goods transport of steam-ships; and, considering that the Society of Arts is distinguished as the parent of no less than 350 Associated Institutions devoted to educational cultivation, and to the practical prosecution of all utilitarian pursuits in science and arts, I appeal to the Society, confident in the expectation that any effort to direct attention to the fundamental bases of steam-ship capability—namely, "tonnage" and "power"—as standard units of admeasurement, in such manner as to construct thereon some system of steam transport £ s. d. *arithmetic*, will not fail of being countenanced by the Society, and promulgated for the consideration of its numerous associated correspondents, with a view to its being matured and rendered practically useful.

In the prosecution of this inquiry the course which I propose to follow demands that I solicit the indulgence of the members of this Society, because, in the first place, I shall have to dwell on matters purely rudimentary, and the statistical character of the inquiry is suited rather for private study than for open dissertation; also, in the desire to be specific, repetitions will frequently occur. Thus, claiming your indulgence, I purpose to direct attention to the following points for consideration:—

1st. What is the builders' tonnage of a ship? What is the displacement of a ship? And, by reference to examples of steam-ship construction, to show that these two terms have practically no approximate ratio whatever to each other.

2nd. What is the nominal horse-power of a marine engine? What is the working power of a marine engine? And, by reference to examples of marine engine construction and practice, to show that these terms have no approximate ratio to each other.

3rd. To illustrate, by examples of steam-ship construction, the ratio of tonnage to nominal horse-power, which ratio is popularly regarded as expressing the efficiency of a steam-ship, as compared with the ratio of displacement to working horse-power, on which the locomotion of steam-ships is really dependent.

4th. To determine and define the measure of the unit of power which we assign to the term "horse-power," and also the unit of measure which we assign to the term "ton of displacement," as the fundamental basis of our calculations.

5th. To explain the law of resistance by which the motion of a ship is conventionally assumed to be affected, and enunciate the *rule* deduced therefrom, which may be regarded as sufficiently accurate to be practically available for calculating, approximately, the relation of displacement, power, and speed, in vessels of similar types of build, and for comparing the dynamic or locomotive capabilities of different types of build.

6th. To show the extent to which the co-efficients of steam-ship efficiency, resulting from the rule above referred to, differ from each other, thereby exposing the difference of locomotive efficiency between one ship and another.

7th. Assuming any given type of form, and any given size of ship, show the mutual relation of speed, distance, and cargo.

8th. To propose a system of arithmetical deduction whereby the cost of upholding and working steam-ships may be approximately calculated; and, by way of example, assuming a given type of build and given size of ship, show the mutual relation of speed and £. s. d. prime cost expenses incurred in the conveyance of goods on a given passage per ton weight of goods conveyed.

9th. To show the extent to which the cost of goods transport is affected by differences in the size of the ships employed, their co-efficients of dynamic or locomotive duty and other constructive data being the same.

10th. Assuming a given type of build, show the extent to which the cost of goods transport is affected, according

as it may be required to perform the whole passage direct without re-coaling, or to re-coal at certain intermediate stations.

11th. Show the extent to which the prime cost expense of goods transport per ton weight is affected by differences in the dynamic quality of the ships employed, as measured by the difference of their co-efficients of locomotive efficiency.

Recurring, now, to the foregoing divisions of our subject, taken in their order, it may be observed:

Firstly. The builders' tonnage of a ship, still usually adhered to, though now denominated as the old measurement, is determined as follows: Rule. From the length of the ship (measured between the perpendiculars of stem and stern in feet) take three-fifths of the beam, multiply by the beam, and by half the beam, and divide by 94, the result is the builders' tonnage.

For example; take H.M. steam-vessels *Fairy* and *Bruiser*:—*Fairy*, length 144 feet 8 inches, breadth 21 feet 1½ inches, tonnage 313. *Bruiser*, length 160 feet 6 inches, breadth 26 feet 6 inches, tonnage 540.

It will thus be observed that the tonnage makes no specific reference either to the depth of hold or to the draught of a ship.

The displacement of a ship is the cubical measurement of the quantity of water displaced by the hull of the ship, and, when immersed down to the constructor's deep-draught line, it is called the load displacement. The measurement is easily taken from the builder's drawing, showing the lines of the ship, and is dependent not only on the length, breadth, and draught of the ship, but also on the contour of the lines, whether it be full or sharp. The cubical measurement being thus ascertained, the weight of water displaced is readily deduced therefrom at the rate of 36 cubic feet of water to the ton weight, which will be exactly equal to the weight of the floating mass. Occasionally, builders supply the owners of ships with a statement termed *Scale of Displacement*, showing the weight of the water displaced by the hull of the ship, and therefore the weight of the floating body and its load as it becomes gradually immersed down to the constructor's deep-draught line. For example: displacement of the *Fairy* at the constructor's deep draught of 5 feet, is 176 tons weight; *Bruiser* at 14 feet, is 1013 tons weight. Hence, by again referring to the statement of tonnage, it appears that, in the *Fairy*, the ratio of tonnage to displacement is in the proportion of 313 to 176; that is, each 100 tons of tonnage, builder's measure, gives 56 tons weight of displacement; but in the case of the *Bruiser*, the ratio of tonnage to displacement is in the proportion of 540 to 1013; that is, each 100 tons of tonnage, builder's measure, gives 188 tons weight of displacement.

Thus, it appears that two ships on the respective types of the *Fairy* and the *Bruiser*, may be of precisely the same builders' tonnage, say 1000 tons; but the displacement of the one will be 560 tons, and of the other 1880 tons; and supposing the weight of the respective ships and their machinery and equipment, when ready for cargo, to appropriate one-half of their respective displacements, the one ship will carry 280 tons of cargo only, while the other will carry 940 tons, that is, the one will carry only one-third the cargo of the other, though both ships are of the same builders' tonnage, viz., 1000 tons. Hence, it appears that the builders' tonnage of ships affords no approximate indication whatever, either of the ship's displacement or of the tons weight of cargo that the ship will carry; and, in like manner, since no notice is taken of the depth of hold, the builders' tonnage affords no certain indication of the capacity of the ship for cargo. This latter defect is approximately corrected by the new measurement of tonnage, but still the new mode of measurement takes no cognisance of displacement, and therefore affords no guarantee of the tons weight the ship will carry when immersed down to the constructors' deep-draught line.

Secondly, as regards horse-power. The nominal horse-power of marine engines has hitherto been determined by a rule which originally may have duly represented the then general practice of steam-engine construction, and the rule was as follows:—

Assume the effective pressure on the piston at 7lbs. per square inch, after making all deductions for imperfection of vacuum, friction, and other drawbacks; next, *assume* that the working speed of the piston is at a given rate, according to a certain specified and tabulated rate of speed dependent on the length of stroke; assume 33,000lbs. raised 1 foot high per minute as the measure of the unit of power to be denoted by the term horse-power; then, multiply the area of the piston expressed in square inches by the assumed effective pressure on the piston (7lbs.); and again, multiply by the speed assigned to the piston expressed in feet per minute, according to the length of stroke: the product is assumed to give the total amount of moving power expressed in pounds raised 1 foot high per minute, which divide by 33,000; the result is the nominal horse-power. For example:—

H.M.S. *Terrible*, 4 cylinders, 72 inches diameter, 8 feet stroke, at 240 feet per minute, 829 nominal horse-power, called 800.

H.M.S. *Banshee*, 2 cylinders, 72¼ inches diameter, 5 feet stroke, at 210 feet per minute, 364 nominal horse-power, called 350.

H.M.S. *Elfin*, 2 cylinders, 26⅝ inches diameter, 2 feet 6 inches stroke, at 170 feet per minute, 40 nominal horse-power.

In calculating the nominal power of screw-propeller engines, it has become customary to give the engines credit for the speed of piston actually attained instead of the tabular speed; but this practice is not enforced by any conventional rule, nor is it invariably adopted; and the distinction thus partially introduced between the paddle-wheel engines and screw-propeller engines only adds to the confusion. Hence, the nominal horse-power is based on assumption, not on fact, and by the only recognised rule for calculating power, no notice is taken of the boiler, on which everything depends.

The working horse-power, usually denominated the *indicated* horse-power, (because ascertained by means of an instrument called the indicator), is measured as follows:—

Ascertain, by means of the indicator, the *actual* pressure of steam per square inch on one side of the piston, and the *actual* condition of the partial vacuum on the other side of the piston; these together will give the gross pressure per square inch exerted by the piston. Multiply the area of the piston expressed in inches by the *actual* gross pressure per square inch, and again multiply by the *actual* speed at which the piston moves, expressed in feet per minute, and divide by 33,000. The result is the gross indicated horse-power; and it has been laid down by some acknowledged authorities in such matters that the nett effective power of an engine may, as a general rule, be expected to be 25 per cent. below the gross power; that is, if we divide the gross moving power by the divisor 44,000, instead of 33,000, the result will give approximately the nett effective horse-power as given out by the engines. For example:—the following statement shows the nominal horse-power, the gross indicated horse-power, and the effective horse-power, of H.M. steam ships *Trident*, *Retribution*, *Caradoc*, and *Elfin*, as follows, namely:—

Trident, nominal 350, gross indicated 492, effective, taken at 25 per cent. less than the gross indicated, 369.

Retribution, nominal 400, gross indicated 1092, effective, taken at 25 per cent. less than the gross indicated, 819.

Caradoc, nominal 350, gross indicated 1600, effective, taken at 25 per cent. less than the gross indicated, 1200.

Elfin, nominal 40, gross indicated 244, effective, taken at 25 per cent. less than the gross indicated, 183.

Hence, it appears that in the *Trident* the ratio of the nominal horse-power to the effective horse-power, has been 350 to 369; that is, each 100 nominal horse-power has worked up to 105 effective horse-power.

In the case of the *Retribution*, the ratio of nominal horse-power to the effective horse-power has been 400 to 819;

that is, each 100 nominal horse-power has worked up to 205 effective horse-power.

In the case of the *Caradoc*, the ratio of nominal horse-power to the effective horse-power has been 350 to 1,200, that is, each 100 nominal horse-power has worked up to 343 effective horse-power.

In the case of the *Elfin*, the ratio of nominal horse power to the effective horse-power has been 40 to 183; that is, each 100 nominal horse-power has worked up to 457 effective horse-power.

Thus it appears that four different sets of marine engines may be of the same nominal power, say 100 nominal horse-power, but, nevertheless, their effective powers may be 105, 205, 343, and 457; that is, very nearly in proportion to the numbers 1, 2, 3, 4; that is, the unit of nominal horse-power of the *Trident* is one-half that of the *Retribution*, one-third that of the *Caradoc*, and one-fourth that of the *Elfin*. In other words, the nominal power of a marine engine, though contracted for as a definite quantity, say 100 horse-power, affords no guarantee, not even approximately, of the effective power of the engines to be delivered under the contract.

Thirdly. Such being the anomalies as respects the nominal size of ships expressed by tonnage with reference to their really effective size expressed by displacement, and such being the anomalies as to the nominal power of marine engines with reference to their effective power, it is evident that the ratio of nominal horse-power to tonnage, which is usually quoted as expressing the mechanical efficiency of a steam-ship, is a delusion, in so far that both terms are mere fictions, affording no certain indication of the comparison between the means really employed—namely, the effective horse-power with reference to any definite unit, and the service really performed, namely, the displacement in tons weight actually moved at such speed as may be; to illustrate which, I will refer to a few ships which are nominally powered very nearly alike, that is, in the ratio of about 100 tons of tonnage to 40 horse-power, or $2\frac{1}{2}$ tons of tonnage per nominal horse-power. For example:—

Vessels.	Builders' Tonnage.	Nominal Power.	Ratio of Builders' Tonnage to Nominal Power.
H.M. steam-ship *Encounter* ...	953	360	100 to 38
,, *Conflict*	1038	400	100 to 38
,, *Termagant*...	1547	620	100 to 40
,, *Niger*.........	1072	400	100 to 38
,, *Sharpshooter*	503	200	100 to 40
,, *Undine*	290	110	100 to 38
,, *Fairy*.........	313	128	100 to 41
,, *Garland*......	295	120	100 to 41
,, *Violet*.........	298	120	100 to 40
,, *Elfin*	98	40	100 to 41

Thus, the above-named vessels are nominally powered very nearly alike, namely, about 40 nominal horse-power to 100 tons of tonnage; but in reality, as determined by their actual displacement, and their measured working power, these same vessels are effectively powered as follows:—

Vessels.	Displacement Tons weight.	Effective Horse-power, based on Indicator Measurement.	Ratio of Displacement to Effective Power.
Encounter.....	1482	505	100 to 34
Conflict.........	1628	583	100 to 35
Termagant ...	2312	988	100 to 43
Niger	1454	690	100 to 47
Sharpshooter...	620	306	100 to 50
Undine	250	331	100 to 132
Fairy...........	177	273	100 to 154
Garland........	250	376	100 to 182
Violet	250	434	100 to 177
Elfin	65	183	100 to 281

Hence, it appears that although the before-mentioned steam-ships are nominally powered alike, namely, in the ratio of 40 horse-power to 100 tons of builders' tonnage, and are officially rated as such, the absolute proportions of effective power to tons of displacement in these identical vessels actually fluctuate from 34 horse-power up to 280 horse-power for each 100 tons of displacement. Nevertheless, the locomotive efficiency of steamers is publicly recognised, even by the Board of Trade Mercantile Navy List, as being represented by the ratio of their tonnage to their nominal horse-power, and no cognisance whatever is taken of the displacement of ships at the constructors' load-line draught, or of the available effective power of the engines with reference to any definite unit of motive power. The delusion is recorded and published as fact, the truth is altogether disregarded. Is it possible that the service of steam-ships can be effectively conducted under such a system of uncertainty and delusion in regard to their respective capabilities?

Fourthly. We now come to treat of the dynamic or locomotive operation of steam-ships, and since it is the engine-power that causes a steam-ship to move, and the tons weight of displacement moved at such rate of speed as may be, that constitutes the effect produced, it becomes utterly impossible to treat of and discuss the subject of steam-ship locomotion without defining, in the first place, what shall be the measure of the unit of power which we denominate as marine horse-power. We have already referred to the nominal horse-power as being calculated on assumed limitations, which are no longer recognised in marine-engine practice, and are therefore a mere fiction; but we have referred to the gross indicated power as a reality, in so far that it is an actually measured quantity, based on the definite standard of 33,000lbs., raised one foot high per minute; and the gross measure, as exerted by the piston of an engine, has been, by tacit concurrence, converted into nett or effective working power of the unit above referred to, by the assumption that friction and various other causes of detriment, not definitely measurable, may be fairly expected to obstruct the action of an engine to the extent of 25 per cent.; that is, in order to obtain effective horse-power of the unit 33,000 lbs. raised one foot high per minute, the gross indicated force exerted by the piston, as measured by aid of the indicator, and described in pounds weight raised one foot per minute, must be divided by the divisor 44,000, in order to give effective horse-power of the unit 33,000lbs. raised one foot high per minute; but even this measure of the effective unit of power of marine-engines has been altogether superseded in modern marine-engine practice, and no definite measure has been, by common consent or by legal enactment, substituted in its place. For example, referring to an essay recently published by myself on Steam-ship Capability, page 5, it appears that the engines of ten steam vessels lately employed by the Government as mail packets, namely, *Banshee*, *Llewellyn*, *Caradoc*, *Vivid*, *Garland*, *Violet*, *Onyx*, *Princess Alice*, *Undine*, and *Elfin*, were contracted for and supplied to Government as amounting in the aggregate to 1,840 nominal horse power; but the measured gross indicated power capable of being exerted by these engines actually amounted to a power equivalent to 285,758,000 lbs. raised one foot per minute; which, divided by 1840, gives 155,303 lbs. raised one foot high per minute, as the gross measure of the unit of marine horse-power thus actually delivered under the denomination, nominal horse-power. In consideration, however, that the contractor's supplied engines for the mail packet service exerting an amount of power undoubtedly above the ordinary practice of trade, and considering further that the working power exacted from these mail packets, on the occasions of the proof trials by which the efficiency of the engines was tested, may have been forced beyond the limits of ordinary work, I have allowed 15 per cent. for this excess, and assumed 132,000 lbs. raised one foot high per minute as the gross indicated measure of the unit of power which may be expected to constitute a

marine horse power, and on which I have based my calculations in the essay above referred to. It may, however, be observed, that the commercial result of such calculations is not affected by the measure of power that may be fixed upon as the standard unit of marine horse-power, whether it be 33,000 lbs. raised one foot high per minute, or 44,000 lbs., or 100,000 lbs., or 132,000 lbs., or 155,000 lbs., or any other number; for, in proportion as the measure of the unit may be increased or diminished, so will the number of such units be the less or greater to perform a given service; but, for the purposes of arithmetical calculation as to the comparative economy of different ships, it is evidently indispensable that *some definite measure of power be fixed upon as the unit of power*, and that the same measure of the unit be applied to all. In the following calculations, therefore, the unit of the gross marine horse-power as exerted by the piston of an engine, will be regarded as equivalent to 132,000 lbs. raised one foot high per minute, and we shall regard the constructor's load-line displacement in tons weight at the rate of 36 cubic feet of water to the ton, as expressing the size of a ship on which we base our calculations; observing, however, that this measurement will not represent, or be any certain indication of, the entire capacity of the ship with reference to roomage for measurement goods. Equity requires that the builder be paid with reference to size or roomage, as one element of the building cost, but science requires that the work performed by a steam ship be ascertained with reference to the tons weight as measured by the ship's displacement, combined with the speed at which the ship may be propelled.

Fifthly. Our next step must be to determine the formula or "rule," whereby the law of resistance, as expressed by the mutual relations of displacement, power, and speed, in vessels of similar form, worked by engines of corresponding efficiency, may be most satisfactorily represented. The writer of this paper referring to the labours of others on this subject, and without impugning their conclusions, has been practically brought to the opinion that theoretical investigations in search of the form of vessel that shall give the greatest locomotive effect with a given amount of power, generally result in mathematical complications of too abstruse a character to be practically available, and that the theoretical deductions which may be thus arrived at would, after all, require experimental confirmation before being taken for granted. Our object is to determine what ships actually do, not what they theoretically ought to do. It is, therefore, presumed to be only by the result of actual experience, not of mere models of ships, but of ships themselves, that the type of form best adapted for locomotive duty will be ascertained. By adopting this principle of practical trial, though we may not arrive at perfection, we may obviate unheeded retrogression, which has hitherto been the bane of steam-ship constructive progress, and by taking the chance of occasionally getting a small step in advance of all previous types of build, we shall progress towards the attainment of perfection at which it may never be said that we have absolutely arrived.

This course of procedure, however, evidently demands that we determine upon some standard rule whereby we may assign some definite number as the index number or coefficient indicative of the dynamic or locomotive efficiency of steam ships, such coefficient being based on the data which the trial of the vessel may actually substantiate. Our object now is to fix the formula or "rule" by which this "coefficient" of locomotive duty shall be calculated. I believe it to be generally admitted that, for all practical purposes, though not strictly correct, the velocity (V) of a steam-vessel will vary as the cube root of the effective power, or as the cube root of the gross indicated power, provided that the effective and gross indicated powers be in a constant ratio to each other; or, in any given vessel the power will vary as the cube of the velocity (V^3) provided the displacement be constant, and friction evanescent. Also, if the speed be constant, the friction evanescent, and the types of form of the immersed hulls be perfectly similar to each other, though different in size or displacement, the resistance at any given speed, and the power to overcome that resistance, will vary as to the maximum cross section (A). Hence, for *similar types of form*, the friction being supposed to be evanescent, we have $\frac{V^3 \times A}{H.P.} = C$, C being some constant number for vessels of similar type of form, and of equal mechanical efficiency, But this formula is not adapted for calculations which involve the weights of the ship and cargo. We must, therefore, convert it into a form embracing displacement. Now, in similar types of form, the lengths, breadths, and draughts of one vessel will be in the same degree proportional to the length, breadth, and draught of another, and the maximum cross section (A) will vary as the square of either one of the analagous dimensions (a^2), whilst the whole cubical dimensions of the immersed hull or displacement (D) will vary as the cube of the same dimension (a^3), or a will vary as the cube root of D, and, therefore, a^2 will vary as $D^{\frac{2}{3}}$; but a^2 also varies as the maximum sectional area (A); consequently the maximum sectional area (A) varies as the cube root of the square of the displacement ($D^{\frac{2}{3}}$); consequently, for vessels of a similar type of form, propelled by engines of equal efficiency, $\frac{V^3 \times D^{\frac{2}{3}}}{H.P.}$ will be a constant number (C). If, however, the hulls be of dissimilar types of form, and the engines not equally efficient, the coefficient (C) will not necessarily remain constant; the different types of form and differences of external surface may affect the resistances in a different degree, and that type of form and engine adaptation thereto will be the best adapted for locomotive duty which, on actual trial of the ship, shall produce the highest coefficient, assuming that the engines be equally effective as respects the ratio of the gross indicated power to the nett effective power, whereby the ship is actually propelled, and which may be tested by means of the dynamometer.

Hence, to test the locomotive efficiency of a steam-ship, let the vessel be tried by successive runs over a given distance; let the displacement of the hull at her trial draught be accurately measured; also, let the gross power as measured by means of the indicator, and the corresponding speed, either in knots or in statute miles per hour, be ascertained; then observe the following rule:—multiply the cube of the velocity (V^3) by the cube root of the square of the displacement ($D^{\frac{2}{3}}$), and divide by the gross horse-power: the result will be the numeral coefficient (C), which denotes the locomotive efficiency of the ship, or, in other words, the constructive merit of the type of form combined with engine adaptation thereto.

If the comparative efficiency of the engine department alone is to be determined, it may be effected approximately by working the engines at moorings, and ascertaining the ratio between the effective power as determined by the dynamometer and the gross power as determined by aid of the indicator, and at the same time taking the consumption of coal per hour with reference to the gross indicated power; and if the comparative efficiency of different types of form be required irrespective of the engine department, then the nett effective horse-power must be determined by aid of the dynamometer, and substituted in the above mentioned formula for the gross indicated horse-power.

Sixthly, assuming the rule:—multiply the cube of the velocity (V^3) by the cube root of the square of the displacement ($D^{\frac{2}{3}}$), and divide by the horse-power (H.P.) as producing a numeral co-efficient or index number approximately indicative of the relative constructive merits of vessels as respects their types of form and engine adaptation thereto, I will now give a few examples of the application of the rule, showing the great difference that exists between one ship and another as respects their locomotive or dynamic efficiency, thence inferring the necessity which exists for such test trials of ships being

more commonly had recourse to, as the most available means of *checking retrogression*, and duly maintaining in new ships our already realised advancement in the art of steam-ship construction :—

Names of Vessels.	Displacement. Tons Weight.	Gross Indicated Power. (Ind. H.P.)	Marine Horse-power. (H.P.)	Speed per Hour. Knots.	Index Number, or Coefficient of Locomotive performance.
Candia . . .	2520	1356	339	12	944
Rattler . . .	1078	436	109	9·64	862
Fairy . . .	168	364	91	13·32	792
Vulcan . . .	2076	793	198	9·6	728
Arrogant . .	2444	623	156	8·3	664
Dauntless. .	2251	1218	304	10·29	616
Niger. . . .	1323	920	230	10·43	592
Conflict . . .	1443	777	194	9·29	528
Termagant .	2370	908	227	8·55	492
Dwarf . . .	98	216	54	10·54	460

Thus, the coefficient of locomotive duty of the *Candia* (944), is about 30 per cent. superior to that of the *Vulcan* (728), and upwards of the double, or 100 per cent., superior to that of the *Dwarf* (460), though the engines of these three vessels were all made by the same manufacturer; the effect of which is, that, supposing two vessels of, say, 2500 tons displacement, of the respective types of form and engine adaptation thereto of the *Candia* and the *Dwarf*, the former would be propelled at the speed of ten knots per hour, by 196 marine horse-power of the unit 132,000 lbs. raised one foot high per minute, while the latter would require 400 marine horse-power to be propelled at the same speed.

It must be observed that, in this great difference of locomotive efficiency between the *Candia* and the *Dwarf*, there are involved not only the known differences of type of ships' form and difference of engine efficiency, but also probable difference of resistance resulting from difference of friction from the immersed hull being possibly cleaner in one case than in the other; also, possible differences of engine management, the one engine probably being screwed up or packed too tight, and the other running free. The difference of the co-efficients in the cases referred to, shows that a positive malconstruction, or defective condition, or bad management, or abuse of some kind, exists to the extent of about 100 per cent.; and being thus proved to exist, the cause thereof should be inquired into, detected, and remedied, if remediable; or, possibly, it may be better to condemn an inferior ship, rather than run her at the disadvantage of incurring 100 per cent. extra expenses in the engine department of her service. (See Note at end of Paper.)

In mercantile steam-ship navigation, no method whatever of a definite description, such as that above described, has ever been adopted for testing the capability, condition, and management of steam-ships. The sacrifice of national interests, from vessels being ill-adapted for the most economical performance of the service required of them, is, probably, enormous, and, in my opinion, attributable to no specific quantities having been assigned to the terms *tonnage* and *horse-power* as standard unit measures applied to steam shipping. This deficiency in legislation requires correction, for, without such correction, inquisitorial arithmetic, as applied to steam navigation, can have no sound fundamental starting point; and the Society of Arts, more appropriately than any other, may undertake the task of effecting so desirable and so important a reform.

Seventhly. Presuming that the foregoing rule be admitted as representing, with sufficient accuracy for practical purposes, the mutual relations of displacement, power, and speed, in vessels of homologous construction, and that the numeral value of the coefficient or index number (C) be determined for a whole class of vessels of similar type by the actual test trials of any particular ship, we thus have the means of arithmetically developing the mutual relations of displacement, power, and speed, for all vessels of that constructive type; and I now proceed to develop, in the first place, the mutual relation of speed and power, assuming the size of the vessel at 1,500 tons displacement, and that, on test trial, the engines working at 240 horse-power, gave 12 knots per hour, whereby the coefficient of locomotive efficiency would be 944, the unit of power being taken at 132,000 lbs. raised 1 foot high per minute. In this case, the horse-power required for propelling a vessel of 1,500 tons displacement at variations of speed from 6 knots per hour up to 20, would be as follows:—6 knots, 30 horse-power; 7 knots, 48; 8 knots, 71; 9 knots, 101; 10 knots, 139; 11 knots, 185; 12 knots, 240; 13 knots, 305; 14 knots, 381; 15 knots, 468; 16 knots, 569; 17 knots, 682; 18 knots, 809; 19 knots, 952; 20 knots, 1,110.

Thus, it appears that to increase the speed of the ship one knot per hour from 8 knots to 9, requires that the power be increased from 71 to 101 horse-power, being an increase of 30 horse-power; but, to accelerate the speed one knot from 16 knots to 17, requires that the power be increased from 569 horse-power to 682 horse-power, being an increase of 113 horse-power, being 4-times the power required for the one knot increase from 8 knots to 9; and if we would double the speed of a steam-ship of given displacement, say from 8 knots to 16, we must increase the power from 71 horse-power to 569 horse-power, being 8 times the power; and as this increase of power must be effected without increasing the deep-draught displacement of the ship, the weight of remunerating cargo will be reduced by an amount equal to the increased weight of machinery, and the increased quantity of coal that will now be required for the passage on which the ships may be employed.

Further, in order to show the capabilities of this ship of 1,500 tons displacement on the type of the *Candia*, with reference to the conveyance of cargo on a given passage, say for 3000 nautical miles without re-coaling, we must assign some definite limit to the weight of coal consumed per hour per horse-power; and since, in my own experience, I am not aware of any steam-ship service fitted with condensing marine engines, as now generally in use, having been permanently prosecuted with a less consumption of fuel than at the rate of 4½ lbs. per indicated horse-power per hour, which is 18lbs. per hour per marine horse-power of the unit 132,000 lbs. raised 1 foot high per minute, therefore, I assume the consumption of coal at that rate, also the weight of the machinery and engine equipment is taken at 5 cwts. per indicated horse-power, or 1 ton per marine horse-power of the unit 132,000 lbs. raised one foot high per minute, and the weight of the hull and its equipment complete, exclusive of the engine department, being supposed to appropriate 40 per cent. of the deep displacement, we have results as follow:—

If the vessel of 1,500 tons deep displacement be powered for steaming at six knots per hour, the passage of 3,000 nautical miles without re-coaling would require 125 tons of coal, and there would be 745 tons of displacement available for cargo; the weight of cargo in this case being 49 per cent. of the deep displacement.

But if the vessel be powered for eight knots an hour the consumption of coals would be 222 tons, and the cargo would be 607 tons; the weight of cargo in this case being 40 per cent. of the deep displacement.

If the vessel be powered for ten knots per hour, the consumption of coal would be 347 tons, and the cargo would be 414 tons; the weight of cargo in this case being 28 per cent. of the deep displacement.

And if the vessel be powered for twelve knots per hour, the consumption of coal will be 500 tons, and the displacement available for cargo will be 160 tons; the weight of cargo in this ease being only 11 per cent. of the deep displacement.

Hence, assuming steam-vessels, on the type of the *Candia* and other data, as specified, of 1,500 tons deep displacement as the size of steamers employed upon a commercial transport service on a passage of 3,000 nautical miles, it appears that if the vessels be fitted for the speed of six knots per hour, the displacement available for cargo will be 49 per cent. of the deep displacement; at eight knots per hour the cargo will be 40 per cent. of the deep displacement; at ten knots per hour, the cargo will be 28 per cent. of the deep displacement; and at twelve knots per hour, the cargo will be only 11 per cent. of the deep displacement.

Eighthly. The foregoing statement exemplifies the mutual relation of speed and cargo, as respects the sacrifice of dead weight of cargo consequent on increasing the rate of speed; but at the same time that cargo is reduced by increased speed the charges are increased, and, consequently, the commercial sacrifice consequent on increasing the rate of speed will be more comprehensively demonstrated if by any means we can form an approximate £ s. d. estimate of the prime cost expenses that attend the steam conveyance of mercantile cargo per ton weight of cargo conveyed.

For the details of such an inquiry I may refer to pages 76 and 77 of the second edition of the essay on Steamship Capability before referred to, whereby, including five per cent. per annum for interest on investment, ten per cent. per annum for upholding stock, and five per cent. per annum for insurance, the annual working charges in the ship department per ton of displacement (assuming the builders' tonnage and displacement to be equal) amounts to £6 11s. 2d., and the annual working charges of the engine department to £7 18s. per indicated horse-power, or £31 12s. per marine horse-power, exclusive of coals; the cost of coals being greatly dependent on the locality of the proposed service and state of the times, requires to be made a distinct item of charge; but for the purpose of exemplifying the proposed system of calculation, I assumed the cost of coal delivered on board ship at 40s. per ton.

For example, on this estimate, the annual prime-cost expenses attending the upholding and working a ship of 1500 tons deep displacement, fitted with engines of 140 marine horse-power of the unit 132,000 lbs. raised one foot high per minute, will, exclusive of coal, amount in the engine department, to £4,424 per annum, and in the ship or hull department to £9,837 per annum, exclusive of coal, harbour and other local dues, lights, and pilotage; and this annual charge against the ship of £9,837 for the ship department, and £4,424 for the engine department, is absolutely irrespective of the locomotive capability of the ship, or of the service that may be performed by the ship, and on which the earnings of the ship will be dependent. Now in consideration that a steamship may be expected to be at sea only, say, 200 days per annum, and that it is only at sea that she does the service which must meet the total annual expenditure, it follows that in the ship department the outlay must be rated at 8d. per day, sea time, per ton of displacement, and the expenses in the engine department at 3s. per horse-power per day, sea time, exclusive of coals, which may be rated at 40s. per ton. For example: On these data, the prime-cost expenses per ton weight of cargo conveyed on a passage of 3,000 miles, by vessels of 1,500 tons deep displacement, fitted for the respective speeds of 6, 8, 10, and 12 knots per hour, and supposing them to be at sea 200 days per annum, and to be fully loaded both out and home, may be estimated as follows:—

Passage, 3,000 nautical miles; ship, 1,500 tons deep displacement; co-efficient of locomotive efficiency that of the *Candia*, or $\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} = 944$. Engine department rated at 3s. per horse-power per day, and coals at 40s. per ton. Shipping department rated at 8d. per ton of deep displacement per day.

Speed in Knots.	Horse-power.	Assumed weight of: Hull.	Engine Department.	Total.	Time.	Coal.	Cargo.	Deep displacement.	ITEMS OF EXPENSE.	Expenses per Ton of Cargo. £	s.	d.	Total.
		Tons.	Tons.	Tons.	D. H.	Tons.	Tons.	Tons.		£	s.	d.	
6	30	600	30	630	20·20	125	745	1500	Coal ...	0	6	9	1 17 3
									Engine Department ...	0	2	6	
									Shipping Department .	1	8	0	
8	71	600	71	671	15·15	222	607	1500	Coal ...	0	14	8	2 5 11
									Engine Department ...	0	5	6	
									Shipping Department .	1	5	9	
10	139	600	139	739	12·12	347	414	1500	Coal...	1	13	6	3 16 3
									Engine Department ...	0	12	7	
									Shipping Department .	1	10	2	
12	240	600	240	840	10·10	500	160	1500	Coal...	6	5	0	11 16 10
									Engine Department ...	2	6	10	
									Shipping Department .	3	5	0	

From the above table we observe, that with vessels of 1,500 tons deep displacement employed on a passage of 3,000 nautical miles, the rates of prime cost expenses per ton of goods consequent on steaming at the speeds of 6, 8, 10, and 12 knots per hour, will be £1 17s. 3d., £2 5s. 11d., £3 16s. 3d., and £11 16s. 10d.; which rates of prime cost freight charge are nearly in proportion to the numbers 100, 120, 205, and 638. It is to be observed that the total expense at 8 knots, is about 20 per cent. in excess of the 6 knots speed, while the saving of time is 25 per cent.; consequently, it may be advisable that the steaming capability of steamers should be not less than 8 knots per hour. We must, however, be cautious how we exceed the speed of 8 knots per hour; for, at 10 knots, the prime cost freight charges, under the circumstances of this case, become 70 per cent. in excess of the 8 knots speed; and, at 12 knots, the displacement available for cargo is so reduced that the prime cost freight charges per ton of cargo become five times greater than the expenses incurred at 8 knots.

Ninthly. We may now usefully enquire into the effects that will be produced by increasing the size of the ship. Suppose, therefore, that we employ a ship of double the

before-mentioned size, namely, 3,000 tons deep displacement, on the same 3,000 miles passage, and under the same conditions as to consumption of coal and other details of estimate, the results will be as follow:—

Passage 3,000 nautical miles; ship, 3,000 tons deep displacement; co-efficient of locomotive efficiency $\frac{V^3 D^{\frac{2}{3}}}{H.P.} = 944$.

Speed in Knots.	Horse-power.	Assumed Weight of Hull.	Assumed Weight of Engine Department.	Assumed Weight of Total.	Time.	Coal.	Cargo.	Deep displacement.	Items of Expense.	Expenses per Ton of Cargo. Items.	Expenses per Ton of Cargo. Total.
		Tons.	Tons.	Tons.	D. H.	Tons.	Tons.	Tons.		£ s. d.	£ s. d.
6	48	1200	48	1248	20·20	200	1552	3000	Coal	0 5 11	
									Engines	0 1 11	1 14 8
									Shipping	1 6 10	
8	113	1200	113	1313	15·15	353	1334	3000	Coal	0 10 7	
									Engines	0 4 0	1 18 0
									Shipping	1 3 5	
10	220	1200	220	1420	12·12	550	1030	3000	Coal	1 1 4	
									Engines	0 8 0	2 13 7
									Shipping	1 4 3	
12	381	1200	381	1581	10·10	794	625	3000	Coal	2 10 10	
									Engines	0 19 1	5 3 3
									Shipping	1 13 4	

From the above table we observe, that with vessels of 3000 tons deep displacement (being the double of the size before referred to) employed on a passage of 3000 nautical miles, the rates of prime cost expenses per ton of goods consequent on steaming at the speeds of 6, 8, 10, and 12 nautical miles per hour, as compared with the expenses incurred with the 1500 tons ship, will be as follows:—namely,

£1 14s. 8d., £1 18s. 0d., £2 13s. 7d., and £5 3s. 3d., instead of £1 17s. 3d., £2 5s. 11d., £3 16s. 3d., and £11 16s. 10d., being a saving in favour of the large ship of 2s. 7d., 7s. 11d., £2 2s. 8d., and £6 13s. 7d. per ton of goods conveyed, or equivalent to 7 per cent., 17 per cent., 30 per cent., and 57 per cent., showing the advantage of the increased size according as the speed at which the service may be required to be performed shall be 6, 8, 10, or 12 knots per hour. Thus, we see the advantage of the larger ship in performing a *given service* under the *same conditions* of speed and distance to be run without re-coaling, provided that it be always fully loaded, and that its harbour services of loading and discharging cargo be performed with equal dispatch, and that neither mercantile, or local, or naval difficulties, subject the larger ship to inconveniencies not affecting the smaller.

Tenthly: on the other hand, however, let us suppose that the smaller ship of 1,500 tons avail itself of re-coaling at ports not accessible to the large ships of 3000 tons, and that instead of performing the whole passage of 3000 nautical miles direct without re-coaling, it divides the passage into 3 stages of 1000 miles each, re-coaling at the two intermediate stations. Under these conditions, the cost expenses per ton of goods conveyed the whole distance will be as follows:—

Passage, 3000 nautical miles, performed in 3 stages of 1000 miles each; ship 1500 tons deep displacement, co-efficient = 944.

Speed in Knots.	Horse-power.	Assumed Weight of Hull.	Assumed Weight of Engine Department.	Assumed Weight of Total.	Time per Stage.	Coal per Stage.	Cargo.	Deep displacement.	Items of Expense.	Expense per Ton of Cargo. Items per Stage.	Expense per Ton of Cargo. Total for Stage of 1000 N. Miles.	Expense per Ton of Cargo. Total for Passage of 3000 N. Miles.
		Tons.	Tons.	Tons.	D. H.	Tons.	Tons.	Tons.		£ s. d.	£ s. d.	£ s. d.
6	30	600	30	630	6·23	42	828	1500	Coal	0 2 0		
									Engines	0 0 9	0 11 2	1 13 5
									Shipping	0 8 5		
8	71	600	71	671	5· 5	74	755	1500	Coal	0 3 11		
									Engines	0 1 6	0 12 3	1 16 10
									Shipping	0 6 10		
10	139	600	139	739	4· 4	116	645	1500	Coal	0 7 2		
									Engines	0 2 8	0 16 4	2 9 0
									Shipping	0 6 6		
12	240	600	240	840	3·11	167	493	1500	Coal	0 13 6		
									Engines	0 5 1	1 5 8	3 17 0
									Shipping	0 7 1		

Thus, by re-coaling at two intermediate stations, the cost expenses per ton of goods conveyed, amount to £1 13s. 5d., £1 16s. 10d., £2 9s. 0d., and £3 17s. 0d., according as the speed is 6 knots per hour, 8, 10, or 12 knots, instead of £1 14s. 8d., £1 18s. 0d., £2 13s. 7d., and £5 3s. 3d., the expenses per ton of cargo incurred by

the larger ship of 3000 tons displacement, performing the passage of 3000 miles direct, without re-coaling at any intermediate station. Thus it appears the advantage resulting from the superior capability of ships of 3000 tons displacement, over ships of half the size, namely, 1500 tons displacement, on a passage of 3000 miles, becomes altogether neutralised, and the scale turned in favour of the smaller ship, simply by her taking advantage of re-coaling at two intermediate ports, thus dividing the passage into three stages, instead of performing the 3000 miles direct. In fact, it is the judicious adaptation of speed to the pecuniary rate of freight charges that the description of trade between any two ports will bear, and the judicious selection of the size of ships to be employed with reference to the amount of trade in both directions, and to the coaling stations which may be available, that constitute the very essence of steam ship direction, on which steam ship economy of transport is dependent.

On this point, namely, the relative dynamic or locomotive capabilities of large ships as compared with smaller, I am particularly anxious that I be not misunderstood before the Society of Arts: I do not only acknowledge, but I have also publicly endeavoured to demonstrate, the superior dynamic or locomotive capabilities of large ships for the performance of any given service under given conditions of steaming speed and distance to be steamed without recoaling; but what I would desire to inculcate is, that this mechanical, and, consequently, in a dynamic point of view, economic, advantage of large ships may very soon become sacrificed, if, on the strength of magnitude alone, we impose on the larger ship the obligation of steaming at a higher rate of speed combined with a greater distance without re-coaling, than we assign to the service of the smaller ship. My views as to the most available size of ships are professionally confined to the *mechanical* consideration of the case; I do not enter upon the mercantile and nautical questions by which, apart from engineering, the comparative advantages of large and smaller ships for any particular service, are regulated and limited; but, asserting as I do the superior capabilities of large ships in a dynamic point of view, I would also desire to point out the mechanical limitation of such superior capability, in order that the advantages attendant on size may be realised by vessels having such conditions of service only assigned to them as shall not exceed the limitations which they may be advantageously able to perform.

Eleventhly. The importance of subjecting steam-ship capability for transport service to the test of pecuniary arithmetical calculation, will be illustrated by our bringing into tabulated juxtaposition the £ s. d. prime cost expenses that would be incurred by performing a given service, under given conditions, with vessels of given size (say 3000 tons displacement), but of various locomotive qualities, as indicated by the differences of their dynamic coefficients. For this purpose I have made a selection of ten different types of construction, whose dynamic coefficients have been determined by the actual test trial performance of the respective ships, and calculating the £ s. d. prime cost expenses per ton of goods conveyed by ships of these types of 3000 tons displacement, on a passage of 3000 miles, at the speed of eight knots per hour. The results are as follow:—

Passage, 3000 nautical miles, displacement 3000 tons, speed 8 knots per hour. (*The purpose of this table is to show the mutual relation between the dynamic co-efficient and the £ s. d. cost of transport, the coal being rated at 40s. per ton, engines at 3s. per day per horse-power, and the shipping at 8d. per day per ton of displacement.*)

TYPE OF CONSTRUCTION.	Dynamic (C) Co-efficient.	Speed.	Power.	Weight of Hull and Engines.	Time.	Coal.	Cargo.	Deep displacement.	ITEMS OF EXPENSE.	Expenses per Ton of Cargo. Items.	Expenses per Ton of Cargo. Total.
		Knots.	Horses.	Tons.	D. H.	Tons.	Tons.	Tons.		£ s. d.	£ s. d.
Candia........	944	8	113	1313	15·15	353	1334	3000	Coal	0 10 7	
									Engines . .	0 4 0	1 18 0
									Shipping . .	1 3 5	
Rattler.........	862	8	124	1324	15·15	387	1289	3000	Coal	0 12 0	
									Engines . .	0 4 6	2 0 9
									Shipping . .	1 4 3	
Vulcan	728	8	146	1346	15·15	456	1198	3000	Coal	0 15 3	
									Engines . .	0 5 9	2 7 1
									Shipping . .	1 6 1	
Arrogant ...	664	8	160	1360	15·15	500	1140	3000	Coal	0 17 7	
									Engines . .	0 6 7	2 11 7
									Shipping . .	1 7 5	
Dauntless ...	616	8	173	1373	15·15	541	1086	3000	Coal	0 19 11	
									Engines . .	0 7 6	2 16 2
									Shipping . .	1 8 9	
Hogue.........	602	8	177	1377	15·15	553	1070	3000	Coal	1 0 8	
									Engines . .	0 7 9	2 17 7
									Shipping . .	1 9 2	
Conflict	528	8	202	1402	15·15	631	967	3000	Coal	1 6 1	
									Engines . .	0 9 10	3 8 3
									Shipping . .	1 12 4	
Termagant...	492	8	216	1416	15·15	675	909	3000	Coal	1 9 8	
									Engines . .	0 11 2	3 15 3
									Shipping . .	1 14 5	
Ajax	364	8	293	1493	15·15	916	591	3000	Coal	3 2 0	
									Engines . .	1 3 3	6 18 2
									Shipping . .	2 12 11	
Amphion......	332	8	321	1521	15·15	1003	476	3000	Coal	4 4 3	
									Engines . .	1 11 7	9 1 6
									Shipping . .	3 5 8	

Thus we see that as the dynamic coefficient varies from that of the type of the *Candia* (944) to that of the type of the *Amphion* (332), the prime cost expenses of goods' transport will increase from £1 18s. to £9 1s. 6d. per ton of goods conveyed on the service referred to. No doubt many causes may contribute to this great difference of dynamic or locomotive economy; but, whether the cause be inferiority of type of build, inferiority of engine adaptation, defective condition of hull or engines, bad management, or all of these causes of inefficiency combined, the result is equally detrimental to the commercial interests concerned in the service of the inferior vessel. And further it is to be observed, that the economic advantages of a superior type of build may be sacrificed by an unnecessary weight of materials having been employed in the construction of the ship and engines, thereby encroaching upon the displacement otherwise available for cargo. Hence the advantage of knowing the displacement of a ship at her launching draught, and when fully equipped ready for cargo.

In the case of ships of war, the armament and personal and material equipment constitute a constant cargo, which may be called tons weight of "Naval Demonstration;" and it may possibly be said that the type of build of ships of war, with reference to their dynamic efficiency, is of secondary importance to their type of build, with reference to stability, sailing properties, capability for carrying guns at the bow and stern, and other essential naval requirements. Admitting the force of this argument, the question assumes the following form, namely:—In what naval respects are the types of form illustrated by the *Amphion* and the *Ajax* so superior to the types of the *Hogue* and the *Arrogant* as to compensate for the tons weight of "naval demonstration" in the types of the *Amphion* and the *Ajax*, being only 15 and 20 per cent. of the displacement of ships on those types of construction under the conditions of the assigned service, while the tons weight of "naval demonstration" afforded by the types of the *Hogue* and the *Arrogant* is 36 per cent. and 38 per cent. of their displacement under the same assigned conditions of service. And again, seeing that the types of the *Rattler* and the *Candia*, under the same assigned conditions of service, would carry "naval demonstration" amounting to 43 per cent. and 45 per cent. of their displacement, are we sure that the types of construction of the immersed hulls of the *Rattler* and the *Candia* do not admit of being approximately adopted as giving available immersed lines for ships-of-war. But further, embracing the £ s. d. consideration of the case, it may fairly be asked in what naval respects is the type of construction of the *Amphion* so superior to the type of the *Vulcan* as to make it practically worth while that the conveyance of naval demonstration on board the type of the *Amphion* on a passage of 15 days' duration, at 8 knots per hour, should cost £9 1s. 6d. per ton weight, whilst its conveyance by the type of the *Vulcan* is only £2 7s. 1d. per ton weight? What superiority of naval efficiency have we to show for the difference of transport expenses per ton weight of "naval demonstration," which ships of these types under the conditions of service referred to would respectively involve?

In conclusion, it may be hoped that the discussion of these matters before the Society of Arts, and the truths which such discussion may elicit, will lead to public attention being directed to the necessity of legalising some system whereby the gross tons weight of displacement of ships at the constructors' specified deep-load immersion shall be ascertained; also, that the measure of the unit of power to be denoted by the term horse-power be defined and legalised; and that the records of the Board of Trade embrace the gross tons weight of displacement at the constructors' specified load-line draught, in addition to, and not to supersede, the present record of internal roomage, which latter system of admeasurement may doubtless be necessary for the purposes of fiscal regulation. It is resrpectfully submitted for the consideration of the Society of Arts, that without some legalized definition of the standard units of ships' measurement and of marine engine power, by which steam ships are hired, bought, and sold, and on which their capabilities are dependent, the transport service of steam shipping can not be subject to regulation, or even be brought within the pale of pecuniary arithmetical calculation.

Note.—As the consumption of coals is (*cœteris paribus*) proportional to the gross indicated H.P. actually worked up to, and as the speed is proportional to the distance divided by the time of passage, the locomotive performance of steam-ships may be comparatively tested by the following rule:—Divide the distance steamed (taken in nautical miles) by the steaming time (taken in hours), cube the quotient, multiply by the cube root of the square of the mid-passage displacement, and divide by the average 24 hours' consumption of coals expressed in cwts., the result will be the index number, or co-efficient, indicative of the locomotive performance of the steam-ship. By this rule, the economic operation of the boiler becomes included, and all reference to horse-power being obviated, the elements of this calculation are matters of ordinary counting-house record, and we thus obtain a mercantile rule, divested of engineering technicalities, for comparing the locomotive capabilities of steam-ships.

DISCUSSION.

The Astronomer Royal, F.R.S., says, in a note to the Secretary, "I have made myself acquainted with the paper which is to be read by Mr. Atherton, at the meeting of the Society of Arts, on the 16th instant. I regret much that I cannot conveniently attend the meeting, as I consider the subject brought forward by Mr. Atherton to be very important, and the treatment of it appears to me admirable. I think that Mr. Atherton has most fairly and completely exposed the insufficiency of the usual methods of expressing tonnage and horse-power, and the practicability of substituting for them methods which would be reasonably accurate and generally sufficient. Perhaps I might not entirely agree with Mr. Atherton on the proposed mode of carrying out the substitution. It appears to me that the matter is hardly yet in a state in which any attempt at legalization can be made. It is best, in general, to confirm the adoption of standards by laws only when they have been pretty well established by usage. I should, therefore, turn my thoughts to the introduction of the proposed scales for displacement, or available space, and for effective horse-power, by endeavouring to introduce them to the customary usage of the parties who negotiate the most extensive contracts. I am not sufficiently acquainted with the course of commercial transactions, to say how far reference is made to such scales in the private arrangements of mercantile men, but I conjecture that they are used far more extensively in the contracts of the Government with shipowners than in any other agreements. If this be so, it appears most desirable that the state of the case should be distinctly laid before that branch of the executive government with whom the contracts for hired steamers principally rest; and I should think that if a system of simple rules, to be followed on occasions of contracting for steamers, were laid before the Government, it might be adopted at once by the Government, and might in no long time make its way into the merchant service generally. I have confined my remarks above to the subject of legalising the standards, because this is the principal subject, among those treated in this paper, which it is not in the power of every commercial man to carry out for himself, but I am far from considering this as the only matter of importance in the paper. The discussion of the advantages and disadvantages in the employ of large or small ships, and in the coaling for long or short voyages, appears to me excellent, and will tend, I trust, to remove some extensive delusions on these points."

Capt. J. M. Laws, R.N., was induced to make a few remarks on the very important subject treated of by Mr. Atherton. There were now about 570 vessels propelled

by steam power, either the property of the state, or actually and actively employed by it, embracing an amount of power, capital, and skill, not only unsurpassed by any nation in the world, but unequalled by all nations in the world put together, nor could all the other nations on the earth supply this fleet (dispersed as it was) with fuel and other requisites to sustain its mechanical power. Now, on looking over the Navy List, which gives the nominal horse-power, and the naval demonstration by the number of guns, and also the Commercial List published by the Board of Trade under a recent Act of Parliament, which gives in this case the tonnage and the nominal horse-power, what did we find, why, out of 270 of her Majesty's ships, the force of which varied from 2 to 131 guns each, we have the nominal horse-power *per gun* varying from 175 to a gun to 3 to a gun, with like inequalities of steam power to military force only in degree less throughout the whole list. For instance, we might begin with the *Agamemnon* of 600 horse-power and 91 guns; the *Algiers* of 450 horse-power and 90 guns; the *Arrogant* of 360 horse-power and 46 guns; the *Aurora* of 400 horse-power and 50 guns; the *Argus* of 300 horse-power and 6 guns; the *Blenheim* of 460 horse-power and 60 guns; the *Brunswick* of 400 horse-power and 80 guns; the *Bull-dog* of 500 horse-power and 6 guns; the *Centaur* of 540 horse-power and 6 guns; the *Centurion* of 400 horse-power and 80 guns; the *Conflict* of 400 horse-power and 8 guns; the *Conqueror* of 800 horse-power and 100 guns; the *Royal George* of 400 horse-power, and 120 guns; the *Dauntless* of 580 horse-power and 33 guns; the *Cruizer* of 60 horse-power and 17 guns; the *Curlew* of 60 horse-power and 9 guns; the *Cyclops* of 320 horse-power and 6 guns; the *Curacoa* of 350 horse power and 30 guns; the *Desperate* of 400 horse-power and 8 guns; and, lastly the *Duke of Wellington*, of 700 horse-power and 131 guns. It was unnecessary to pursue the list further, as similar discrepancies, in proportion to the number of ships, would be found under every letter of the alphabet. Some, for instance, the *Royal George*, of 120 guns and 400 horse-power, and the *Conflict*, of 8 guns and 400 horse-power, were both now and had been last year in the Baltic fleet, and the *Royal George* had always worked well, although not built for steam power of any kind. What the *Conflict* had done was not so well known, but had the engines of these two vessels been alike in all other respects, as well as in nominal power, it might have been supposed that she was kept in reserve to any of the line-of-battle ships with the same power; but no such arrangement was contemplated, for both engines and boilers were as unlike in pattern as a knife was to a fork. He would now refer to the two largest private royal companies, and see how they stood, possessing as they did in each case, as regards the number and magnitude of their ships and nominal power of engines, a capital that few if any other national fleets could produce. He would begin with the Royal West India Mail Steam Packet Company. In the last half-yearly report of that Company, just published, a list was given of the company's fleet, and the registered tonnage and nominal horse-power of each ship was stated, amounting, in the aggregate, to 43,524 tons and 11,140 nominal horse power. Now few things in the military or commercial world could be more extravagant than the discrepancies exhibited in this account. For instance, the *Parana*, a ship of 3,070 tons, and 800 nominal horse-power, cost the company £123,000, and was said to be a vessel of excellent qualities; while the *Tyne*, of 2,184 tons and 400 horse-power, was said to have performed a voyage of 3,000 miles or more, with a speed of 13¼ knots per hour. Now compare what the best ship in Mr. Atherton's list would carry her cargo at that speed for, and what it would have cost at 10 knots, and then they could show the proprietors of steam-ship companies what they were undertaking in each case. It was desirable, also, that they should know whether the *Parana* had really more indicated or real horse-power than the *Tyne*, and whether it was profitable to carry passengers and mails goods to and from the West Indies at the same price for the one speed as for the other. The West India Mail Company certainly had, next to the Liverpool and New York, probably the best line of 3000 miles voyage that could be selected, but it was vastly more expensive, and involved extremely dangerous and difficult navigation, which the other was free from. In the matter of coals alone, on the New York line, they would not average above 25s. per ton, or they did not do so on the Collins line; and at Boston and Halifax on the Cunard line, ought not to exceed 35s. per ton. With these remarks on the Royal West India Mail Company, he would pass to the Peninsular and Oriental Company, which likewise possessed an excellent fleet. Here we might fairly infer there was a no less want of knowledge as to what was the meaning of nominal horse power. He had lately read an extraordinary account in the *Times* of the 3rd instant, headed "Paddle *versus* Screw," from which he would make the following extract:—

"PADDLE V. SCREW.—SOUTHAMPTON, Wednesday, May 2. —An experiment of an interesting nature, and attended with important results in connexion with steam navigation, has recently been made by the Peninsular and Oriental Steam Company, who, more fully to test the respective merits of the paddle and screw, have altered one of their fine steamers from a paddle-wheel to a screw. The steamer in question is the Sultan, an iron ship of 1200 tons burden, originally fitted with engines of 420-horse power. The alterations now made in the vessel have caused the old machinery to be entirely discarded, and in its place engines of only 210-horse power have been supplied by Messrs. Sumners and Day, of Southampton, with Lamb and Sumners' patent flue-boilers. An opportunity was here afforded of exhibiting the difference in speed caused by the alteration not only in the method of propulsion, but in the power of the machinery. The experiment has not only been successful, but the result is sufficiently extraordinary to merit the attention of scientific men. At the official trip of the Sultan in 1851 with paddle-wheel engines of 420-horse power, the average speed was 10.714 knots an hour. With the new engines, which are precisely half the power of the old ones, but driving a screw, the average speed under steam alone has been 10.4 knots, and, with a light breeze and the fore and aft canvas set, 11·004 knots, the former being very nearly equal to the speed gained when the ship was driven through the water by paddle-wheel engines of such enormously disproportionate force. The slight and almost insignificant difference in speed is not the only advantage gained by the novel change. In place of carrying only eight days' coals, as heretofore, the Sultan can now stow fuel for sixteen days' consumption, has greater accommodation for passengers, and can take 150 to 200 tons more cargo than it was possible to carry before."

Now, he would ask any reasonable man whether, if that account were true, there could be any longer a question as to which was the right mode of propelling ships, and whether the screw was not, as nearly as possible, 100 per cent. better than the paddle, even as regarded the application of power, and independent of the other advantages very justly claimed. He was much struck with this account, and feeling there must be some delusion in it, he took the liberty of addressing a note to Capt. Engledue, the highly and justly valued superintendent of the Company, at Southampton, and asked him whether the account was correct, to which that gentleman replied, that, except in one unimportant point, it was. He then asked for the draught of water, and the exact indicated horse-power under the two circumstances, or trials, in the years 1851 and 1855; from which it appeared that in 1851 the draught of water was 11 feet, while in 1855 it was 10 feet 10 inches, a difference of two inches only, it was true, but which in a large ship like the *Sultan* would materially alter the displacement. The reply as to the horse-power was not in terms that were intelligible to him (Capt. Laws), but assuming that the power was relatively the same in the 420 and 210 horse-power engines, what did this trial amount to? The speed, to be three-fourths of a knot faster with 40 tons less displacement in the first case than that of the late trial, would not give more than

70 per cent. difference in the relative power of the two sets of engines; that was to say 10 knots per hour would be attained with 80 per cent. of the power of 11 knots, and the difference of displacement at that speed would add at least 10 horse-power, thus reducing the per centage to 70 instead of 100 per cent. That advantage was enough to prove the superiority of the screw, which he never doubted, but he fancied that in these two cases the real power executed by the engines was very much nearer alike than was believed. In conclusion, he trusted that the Naval Department of the Government would establish some fixed rules or data to avoid the discrepancies that had been spoken of, and no longer continue to fight in the dark as to what they were paying for, and what duties could be performed by any nominal amount of horse-power.

Mr. J. Scott Russell, F.R.S., Vice-President, begged to join in the expression of the value which every member of this Society, as well as the noble lord in the chair, must attribute to the fact of Mr. Atherton having come forward to open the discussion upon a subject so important and so practical. When he remembered that Mr. Atherton was originally one of the mercantile engineers of this country, that he matured his knowledge in that service, that afterwards he gave to the government the assistance of his great experience and talent, they must feel that it was very kind on his part to come back, as it were, amongst them again, and repay to them some of the experience which he got when one of them, by applying his researches in an endeavour to settle and mature certain principles of determining the steam capabilities of merchant vessels; because, when he talked about transport service, whether for mercantile or for war purposes, was, of course, of very little importance. Now there were a very considerable number of points on which he admitted he agreed with Mr. Atherton; there were, also, a certain number of other points on which he would express his difference of opinion from that gentleman; but he hoped it would be understood that he did so not for the purpose of putting his opinion against that of Mr. Atherton, but of having the subject thoroughly and dispassionately discussed. There was one point on which, he thought, they must all agree—that was, the dreadful mess they were in with regard to "horse-power" and "tonnage;" and he did not think there was, with but one exception, perhaps, any one in that room who would not admit that on this 16th day of May, 1855, they were in a greater mess in regard to nominal tonnage than they ever were before. He would explain this. He had come from the Custom-house that day, after assisting in getting the register of a vessel. He had desired to get the register before the 1st of May, but he had not succeeded; but the result was, if he had succeeded in getting the vessel registered before the 1st of May, she would only have been registered as a ship of 480 tons, but that day he had got a register of that same ship as one of 543 tons; so that, whether tonnage was an imaginary quantity before *or* after, or whether it was an imaginary quantity before *and* after the 1st of May, must be a matter for the meeting to discuss on a future occasion. So much, then, for tonnage. With regard to horse-power they were much in the same difficulty, but he thought he saw something like daylight through this, if not exactly as Mr. Atherton had stated, yet in some such way; because, he observed in the paper, Mr. Atherton used the words "marine horse-power." Now, if they talked of "horse-power" in the old language, as 33,000 lbs., and then if they called the "marine horse-power" what it usually was, viz., 100,000 lbs.—because they knew that marine horse-power was actually three or four times the old fashioned horse-power—

Mr. Atherton—Make it what you like.

Mr. Scott Russell entirely agreed with Mr. Atherton as to the very great expediency, as soon as possible, of establishing some standard of reference, whether for government, or buying, selling, building, or chartering vessels—not by what they were called, but by what they would do. He knew of two vessels that had been chartered by the government—the one was called a ship of 1,450 tons and 300 horse-power.

Mr. Atherton—Is that builder's tonnage?

Mr. Scott Russell—Registered tonnage; which is nearly the builder's tonnage in this case—the vulgar tonnage before the 1st of May—what it was to-day he would not say. This vessel went from 8 to 9 knots an hour, and could carry about 600 tons. There was also another vessel which also went 8 or 9 knots an hour, which also carried 600 tons, but which was only propelled by 80 horse-power—which only burnt the coal of 80 horse-power, which only registered 480 tons; and, therefore, the 600 tons carried to Constantinople in the one vessel, would cost more than the 600 tons carried to Constantinople in the other vessel, in the proportion of 1,450 to 480, and would burn coal over that distance for the same speed, in the proportion of 300 horse-power to 80 horse-power. Well, then, it was quite plain, for building, and buying, and selling, there was something more to be considered than nominal tonnage and nominal power, and he would advise all shipowners never to buy or build a ship for the future either by nominal horse-power or by nominal tonnage. He had long since abandoned that, with those of his customers who would take his advice. The wiser plan was for the owner to pay the shipbuilder by the working capability of his ship. To say, "I want to carry 600 tons from Liverpool to Constantinople, at 9 knots an hour, with the consumption of so many tons of coals, and the same to be a good and serviceable and durable sea vessel, of the first class," and leave the details to the builder. He would thus get what he wanted, viz., a ship to do a given quantity of work, at a given sum of money; and that, he believed, was what his friend Mr. Atherton would desire to see accomplished. He would have them define the work to be done, and would buy and sell and pay for the vessel, as to whether she would do that work or not. He, therefore, agreed in getting some such ordeal to which to bring these vessels, and he had no objection to call it "effective duty," or "locomotive capability," or some phrase equivalent to that. There was, however, one point to which he must call Mr. Atherton's attention, which did not quite chime with what he had been saying, or what he (Mr. Russell) had himself just said, which was this—there was another element of locomotive capability which was applicable to transports and vessels of war. It was the question of accommodating passengers. That was bound up with displacement in another way, and yet was different from displacement. He did not think it entered much as an element into Mr. Atherton's paper, and, therefore, he called attention to it. He would go back again to the examples he had given of the two ships of 600 tons each, with such different rate of power and cost. He should say, the 1450 ton vessel, if hired for carrying troops instead of being hired for carrying dead weight, would have a very much higher value, and that value would probably be in proportion to her nominal tonnage. A vessel of 1450 tons would have a deck available to a large extent for the transport of troops; therefore, such a vessel for troops might be most economical and proper; and thus, in going into the question of troops or passengers, they must take care what formula they adopted, as it did not appear to be an element in Mr. Atherton's formula. The immediate object of his formula seemed to be merely the transport of a certain weight of goods, and he thought the omission must be remarked as very seriously affecting his conclusions. Another point was omitted in the formula, which must find a place in the head of any practical man, viz., the effect of the *change of form* of the vessel which was necessary in passing from a low speed to a high one. It must never be understood that a small, short vessel of small tonnage, when merely magnified to a large scale, was enlarged in the way it ought to be enlarged, if designed for the purpose of getting additional speed. For example, there was one case in Mr.

Atherton's paper, in which he said—a given vessel with a given form would take so much to propel her at 8 knots, so much at 9 knots, so much at 10 knots, and so much at 11 knots. In practice he (Mr. Scott Russell) should never do that. He should not attempt to make the vessel built for 8 knots, either go 10 knots, or 12 knots, or 15 knots, or put power into it to make it do that; because he knew, by dear-bought experience, that to attempt to make a vessel that was suited for 8 knots go 10 knots was a folly—that to attempt to make a vessel suited for 12 knots go 15 knots was another folly, and was a mere extravagant expenditure of force. Luckily he had the example of an experiment that he thought would convince Mr. Atherton that the point of form suitable to speed was a question that deserved to be looked into. When Mr. Atherton spoke of a vessel of 1500 tons displacement, he (Mr. Scott Russell) referred to an experiment of a vessel of exactly 1500 tons displacement, and this vessel was propelled 9·4 knots, with a consumption of coal of 12 cwt. per hour; and again, he had an experiment with the same vessel at 14 knots. According to Mr. Atherton's calculation, this 1500 tons ship at 9 knots would burn 16 cwt. of coal. Take that as the datum. She burnt in this case 12 cwt. of coals, but when he went to 14 knots with his (Mr. Atherton's) vessel, which was not calculated for 14 knots, then he got a combustion of 3 tons of coal per hour, whilst in fact he (Mr. Russell) only got a combustion of 30 cwt. at 14 knots with his own ship; but he begged to remark, that this was a vessel constructed with the specific form necessary to go 14 knots, and failing success she was to have been thrown upon the hands of the builder. That was the way he, as a merchant builder, was obliged to nail his flag to the mast. Say, for example, he bargained to build a vessel for £60,000, a vessel of 1500 tons to go 14 knots an hour, if she did not go that speed he might have to take off £10,000 from the price for every half-knot she went slower. This vessel being designed to go 14 knots, did it with a consumption of 30 cwt. of fuel. He stated this to show that if this vessel had been taken from a fixed type, only having 16 cwt. at 6 knots, she would, on Mr. Atherton's formula, have burnt three tons at 14 knots, whereas his (Mr. Scott Russell's) burnt only 30 cwt. on account of her better form. In the same manner he had another example of a vessel of 590 feet section going 9½ knots with 27 cwt. of coal. That was at variance with Mr. Atherton's data. Therefore he called attention to the fact, that he would require changed data if he transferred his inferences from a vessel of a given form to classes of vessels which varied in form according to the speed they were designed to go. With regard to any crotchet about the screw being so much better than the paddle, or the paddle so much better than the screw, it was not a point that ought to have been brought forward by engineers in a respectable newspaper, intended to be read by engineers, because he remembered the *Sultan* when she was first built, and she was certainly a very capitally built and fast vessel, with 450 nominal horse power, with the old-fashioned paddle-wheel engine. Her piston probably made 18 strokes per minute, and her safety-valve was loaded probably to 7 or 8 lbs., or, if the commander was a courageous man, perhaps to 9½ lbs. But here came a man who was driving these screw engines probably at the rate of 400 or 450 feet per minute, and he (Mr. Scott Russell) had no doubt he had as large a boiler behind these screw engines as would be found behind the paddle-wheel engines. With regard to the Royal West India Mail ships, that was the most remarkable case perhaps that had ever occurred of the want of recourse to some such investigation as Mr. Atherton had laid before them. He (Mr. Scott Russell) recollected the circumstances under which those large vessels were built. They had a fine contract, under which they were to carry the mails at the rate of 9 knots an hour. They succeeded in doing this with vessels of 1200 tons and 400 nominal horse power, but a new contract was entered into, requiring an accelerated speed of a knot, so that the mails should be carried at 10 knots per hour, and they then built ships of double tonnage, put into them engines of double horse power, but did not adapt the shape of the ships to a higher speed, and instead of obtaining, as with a double proportion of power, well bestowed, they might have obtained, 13 or 14 knots, they had, with double the size of ship, double horse power, and double consumption of coals, barely realised the additional knot, for which they had expended so much money. Such were some of the effects which went to show that investigations of this nature tending to clear away professional mysteries and to test men honestly by the work they had done, were very desirable. Investigations of this nature were of the utmost importance, because many might fancy it was the ship builder who controlled the design of a ship, but practically it was not so, but the owner of the ship who dictated her form. A builder was generally trammelled by conditions and limitations, that left him little choice, except to suit the preconceived notions of his customers; and therefore, unless the general public were enlightened, unless ship owners were enlightened, unless they took an interest in a good ship, in a handsome ship, with a good set of engines in her, and became critics of ship-building, they would not have that stimulus applied to the owners of ships which was the sole means of permitting the builders, or, if they liked it, of compelling the builders to obtain the best possible results. Therefore such discussions as this were highly important. He believed it was the want of a general diffusion of knowledge on this subject that led to such dreadful blunders, not in the Royal Navy alone, but wherever a number of people had to do something for which no one was responsible. He would make one observation in reply to the practical remarks which had fallen from the noble chairman at the beginning of the meeting. He was sure the meeting would duly appreciate the spirit in which those remarks were made; because, many of them being practical men, and all of them patriotic Englishmen, there was at this moment no conviction which weighed more deeply upon their minds than this—here are our practical men of business earnestly longing to do something for the assistance of the country in its present difficulties, and we could not do it for want of an organisation which would enable us to give the government the entire benefit of all our resources and our best services. They all longed to see some practical way in which some good could be done, in order to turn all the mechanical powers of England into the service of the government at this moment; and if that were done it would sweep away the resistance of any other country to us. But here was the difficulty, and he was afraid his lordship could not help them out of it. There were no people who knew better than the servants of the government this fact—that they could not, even when servants of the government, get the proper scope for their energy and talents; and the reason was this—"the want of personal responsibility." There were many eminent men present, of high official standing in the government, and he believed he gave expression to their private sentiments on this subject. He would venture to say, if the capable men in the service of the government were placed in their positions with their hands so free and unfettered that each man were permitted to do that which he knew he was most capable of doing for the service of the government, in the manner which he knew to be most effective for the public service, and were charged with the entire and personal responsibility of his own work, a rapid practical amelioration would take place in the execution of public business. The construction of a steamship for the government, if it were the sole work of one man, whose name was openly attached to it as solely responsible for its success, would run a very fair chance of success; but wherever such works were done by boards instead of by individuals, the difficulties in the way of success were nearly insuperable, because personal responsibility was at an end. Instead of this, it was "an office" that did the work, and not the individual. Out came the

office plan—the office plan was built. If it succeeded, there were twenty people ready to claim the authorship of it, but if it failed pity the poor gentleman who originally drew it. For success in steam navigation the name of one individual should be identified with each ship, as personally responsible for her, from the laying of the keel to her final repose in the breaker's yard, and with personal responsibility you would have good ships. If it were possible for the government of this country to make one individual publicly responsible for the success of every separate piece of work done, to attach the name of one individual who really had the doing of that thing to his work in so unmistakable a manner that he should have all the credit and all the discredit of doing that thing well or ill, —if it were possible that each working head of every department, down to the lowest, were personally responsible for all those below him, and these in turn responsible only to those immediately over them, then public works might be managed much in the same way as private works were conducted, and with equally good results. He feared, however, that our system of parliamentary government was hardly compatible with such a system of extensive personal responsibility. These remarks, perhaps somewhat foreign to the subject, were what he could offer in reply to the wish expressed by the noble chairman, that the services of such societies of men as the present might be rendered available to the assistance of certain departments of government. He begged to assure his lordship of the earnest desire of every man in that meeting to place any talents or powers he might possess at the disposal of government, for the great purpose of the defence of the honour of the country in which, probably, most of them felt even a deeper interest at this moment than in any of their private undertakings.

Mr. ANDREW MURRAY said, at that late hour in the evening he would not enter upon the general subject of the paper. He agreed with the Astronomer Royal as to the difficulties in the way of legalising any definite excess of indicator over nominal horse-power, and that this must always depend upon the custom of the trade. The only other points to which at that moment it seemed important to refer, were those to which Mr. Scott Russell had taken exception, that the formula would not apply in the case of vessels employed in the carriage of passengers, nor to vessels with very fine lines built expressly for a high rate of speed. He considered that Mr. Russell must have overlooked the fact, that speed was essentially an element in the formula, and that the same law as to the slow speed being the cheaper speed, held good with passenger ships as well as with any other ships, with the exception, certainly, of feeding the passengers during the longer time of the slower passage, and this became merely a question whether the passengers or the boilers could be fed cheapest during that time. With respect to the second objection raised by Mr. Russell, that the formula was not adapted to vessels of a form designed for high velocities, the author had included in his calculations the vessel giving the highest co-efficient yet known to him or to the public while estimating the performances of the larger vessel. In the experiment referred to by Mr. Russell, a vessel with lines adapted to a speed of 15 knots would give a result at 9 knots superior to that generally obtained from vessels built for the slow speed, and if a large vessel were built with lines adapted for 15 knots, the result for her at 9 knots would be equally good, and the formula would show the full benefit of that result. He (Mr. Murray) contended that the formula was correct as a comparison between vessels of any size of similar character, and cited in support of this opinion the results of the *Duke of Wellington* as compared with the *Hogue*, both being *sailing* ships of good form, and both having had their sterns judiciously altered to receive screw propellers. The velocity of the *Hogue*, with a displacement of 3,050 tons and 813 indicator horse-power, was, upon trial, 8·328 knots per hour. Taking this as a datum for the speed to be expected from the *Duke of Wellington*, the result for her with a deep displacement of 5,070 tons and 2,016 indicator horse-power, ought by the formula to be 9·808 knots; the result on trial was 9·891 knots, showing an error by the calculation of less than one tenth of a knot. If Mr. Russell, therefore, could produce a moderate-sized vessel giving a higher result or a higher co-efficient than any hitherto obtained or known, he would be perfectly justified in claiming that the performances of the large ship now building by him should be judged of on the datum of this superior ship. Mr. Murray called on Mr. Russell to give the displacement and indicator horse-power of the ship referred to. The question of the amount of coal consumed which had been given by Mr. Russell, though equally important, was not the question at that moment under discussion, but the result that could be got out of a ship by indicator horse-power. Some years ago Mr. Murray had attempted to draw attention to the importance of testing the relative efficiency of different steam-ships, and he came to the conclusion that the number of tons register carried at a uniform speed of 10 knots per hour by one ton of coals, was a criterion sufficiently correct for mercantile purposes, and that if a more minute comparison were wished, the number of tons displacement carried at the rate of 10 knots per hour by 100 indicator horse-power should be taken. This proposal had been published,* and it appeared to him to put the matter in a more tangible or practical form than that mercantile men should quote an "Index Number" as a co-efficient of a ship that they might desire a builder to construct for them; consumption of coals per hour to be taken instead of indicator horse-power, if it be desired to test superiority of engine power at the same time as superiority of the form of the ship, combining the engine-maker with the ship-builder.

Mr. CHATFIELD (master-shipwright, Deptford dockyard) said, no one had listened with greater pleasure than he had done to the paper which had been brought before them, and no one was more convinced of the great importance of the objects in view. He felt, however, that the government departments had been rather roughly handled by some of the gentlemen who had spoken, and that the impression on that Society would, he feared, be that very little attention had been paid on the part of government officers to the subjects of displacement and tonnage; that the naval construction of the country was based upon very slender grounds; and that the published tables of the Admiralty were of very little value. With respect to builder's tonnage, the term, though not definite, was used conventionally, but it did not express the tonnage of displacement. In a brig, for example, the builder's tonnage had an approximation to load displacement; but in a frigate, the displacement would be about one-fourth more; in a two-decker, it would be about one-half more; and in a first-rate, or three-decker, about three-quarters more. These were rough proportions—mere generalisations—nevertheless they were worth knowing. The following table gave the exact proportions in four vessels of different sizes:—

Names and Armament.	Builder's Tonnage.	Displacement in tons.	Ratio of Builder's Tonnage to Displacement.
Caledonia 120	2698	4720	1 : 1·75
Cressy 80	2537	3676	1 : 1·44
Thetis 36	1524	1911	1 : 1·25
Espiègle 12	439	466	1 : 1·06

Everything with government contractors had relation to number and quantity, and they took *displacement* (not builder's tonnage) as the basis of their operations. He could tell the motive *sail power* of any class of ships, in proportion to the area of midship section or displacement in tons—the elements upon which Mr. Atherton had laid

* "Rudimentary Treatise on Marine Engines." By Robert Murray, C.E., pp. 129. Weale, 1852.

so much stress, as the fundamental properties by which horse-power in steam-vessels could alone be properly regulated. In reference to proportions he (Mr. Chatfield) would quote the following tabular form :—

Names and Armament.	Area of Sails in square feet.	Area of Mid-ship Section.	Ratio of Sails to Mid-ship Section.	Displacement in Tons.	No. of square feet of Sail Surface to a ton of Displacement.
Caledonia 120	25619	1056	24·2 : 1	4720	5·4 : 1
Cressy 80	28102	850	33.0 : 1	3676	7·6 : 1
Thetis 36	19762	531	37·0 : 1	1911	10·3 : 1
Espiègle 12	8060	229	35·2 . 1	466	17·3 : 1

This, he said, would show that they did not take builders' tonnage as the groundwork of their calculations. He had understood Mr. Atherton to say, why not take the type of build of the *Candia*, which had performed so well, in preference to the type of construction of the *Amphion?* He (Mr. Chatfield) thought it would be impracticable. The *Amphion* was a ship of war, and reqnired a certain amount of *beam* to impart stability, and to afford room for working the guns. He believed that the length of the *Amphion*, in proportion to her breadth, was about as 4 to 1 ; whilst that of the *Candia* was as 7 to 1 ; and perhaps they were both well-proportioned for their respective services. He felt confident that if Mr. Atherton persevered in his system, he would soon establish valuable formulæ adapted to varied circumstances; and he (Mr. Chatfield) entertained a sanguine hope that his friend Mr. Atherton would be the means of effecting a reform in the term "Marine Horse-power," and that that important subject which he had so ably handled this evening would be improved by his knowledge, experience, and untiring energies.

Mr. Andrew Henderson said, for the last seven or eight years he had given a great deal of attention to the subject before the meeting, with a view to bring before the public the absurdity of using builders' tonnage and nominal horse power, as measures of the size, capacity, or efficiency of ships and steamers. He brought the subject before the Institution of Civil Engineers in 1849, and from that time up to the present he had been endeavouring to collect in the archives of that Institution, the statistics of ships and engines of modern construction, but except from the surveyor's department of the Admiralty, he had found very great difficulty in obtaining the particulars which he was desirous of collecting; ship builders and engineers were disinclined to furnish the required information, whilst shipowners and steam ship companies were unable to do so. No doubt, as was stated by Mr. Chatfield, in her Majesty's dockyards everything in connection with naval construction was based upon the most scientific calculation of the displacements and other elements of stability, resistance, &c. Notwithstanding the difficulties, he had persevered in obtaining a record of the size, proportion, form, and engine power of the principal steamers, as well as the speed actually realised over an extended mail tervice; for he considered that actual service at sea was she only guide in the application of science to the improvement of our shipping. He obtained, through Lord Jocelyn's Committee on Steam Communications, a return of six years' mail service between England and India, and found, as had been stated of the West India mail steamers, that those to the East fell far short of the contract speed. The following were some of them :—the *Haddington* ran over 114,000 miles, at an average speed of 8·94 knots per hour; the *Precursor* made the same speed over 38,000 miles; the *Hindostan* and *Bentinck* less than 9 knots: and on an aggregate of 1,271,000 miles, the speed realised only averaged 7·945 knots per hour. The Parliamentary Return, No. 693, Session 1851, gave the speed realised by each vessel, including some of the Royal Navy and of the Indian Navy. The speed realised, as compared with the displacement and working power of the engines of these vessels, would be a fair criterion of their relative efficiency, but it was most difficult, in consequence of the terms "tonnage" and "nominal horse-power" being, as stated by Mr. Atherton, "absolutely indefinite." Moreover, in short runs, both the displacement and engine-power were constantly varying quantities, so that the average speed on very long runs was a great desideratum towards a fair comparison of the locomotive capabilities of different ships. He considered we owed much to Mr. Atherton for the able manner in which he had brought forward this most difficult question, and particularly its classification under different heads of inquiries. His (Mr. Henderson's) information was derived from practical experience at sea from a very early age. He should confine his observations to questions that had been brought under his notice through his connection with merchant shipping. With respect to the first three points discussed in Mr. Atherton's paper—the tonnage and displacement—the nominal and effective horse power—and the relations between them, they had been the subject of much inquiry by him. In a tabular statement which he had prepared there was given an analysis of some 30 steamers, which he submitted to the consideration of Mr. Atherton and those interested, as containing information and results as to the dimensions, displacement, weight, elements of resistance, engines, and steam power, and speed realised. Some particulars were also given as to the different modes of measurement for tonnage, together with diagrams of the midship sections of many of the principal vessels, on paper ruled to a scale, by which it was intended to show the practicability of ascertaining the actual displacement and area of midship section immersed (or resistance) at any draft, by a scale. This met two of the requirements of the paper. The Tonnage Committee of 1821 considered some fourteen plans of measurement for tonnage, and in their report in 1828 they recommended the displacement measurement of Mr. Parsons, which, by a very simple rule, measured the external bulk of the ships. But it was not carried out, being objected to by the Custom-house, and the old rule was in operation for some ten years, when it was altered to the system of internal measurement of four depths and five breadths. This was again modified in 1845, but was so unsatisfactory as to cause the appointment of the Committee of 1849, of which Lord John Hay was chairman. This Committee recommended the external measurement in cubic feet to the height of deck as the basis of tonnage register, and to approximate the old tonnage on which the Custom-house returns of trade and shipping, as well as the Board of Trade statistics throughout the country were based. Experimental measurements of the external bulk (or displacement to the upper deck in cubic feet), were made of some thirty vessels, and these were compared with their old tonnage. The result of this average gave the factor of 27 hundredths of the external bulk, representing an approximate tonnage by the old tonnage. In 1849 the Tonnage Committee, including Mr. Parsons, Mr. Morsom, some shipowners and naval officers, reported, "that the equitable basis of charges for dock, light and other dues, was the entire cubical contents measured externally to the height of the upper deck, by the use of diagrams and curves of areas." In 1850 a bill was brought into Parliament to carry out this recommendation, as it would give a scale of displacement by which the real capacity for cargo would be known. The bill was opposed by the owners of light timber-built ships and the builders of iron ships, both of whom desired to continue the internal measurement. The builders of iron ships obtained a larger tonnage by internal measurement than the external displacement on tonnage, as had been described by his friend, Mr. Scott Russell, who was himself amongst the number of objectors to external measurement. The

subject was again discussed in 1852, when he (Mr. Henderson) said, if they wanted to ascertain the tonnage they must take both the external and the internal measurements, and the mean of those two should be the basis of the tonnage. No other committee was appointed, and Mr. Morsom's plan of internal measurement was adopted. The builders of iron ships obtained a larger tonnage than timber ships by internal measurement. In 1850 he brought before the Board of Trade a proposal to adopt the recommendation of the committee, that the mean of the external bulk and the internal space should be taken as the basis of register tonnage. In 1852 it was again discussed, and in November of that year he repeated his proposal to the Board of Trade, accompanying the suggestions by plans and forms showing the facility with which the measurements could be made. He also added a scale of displacement and of capacity. The certificate of survey should give a plan and specification of the ship, so as to afford information as to the efficiency of the ship. A change of ministry taking place, as had been observed by the noble chairman, these and other practices and improvements were disregarded, and the question taken up in the routine of the Custom-house business. In 1853-54 the Merchant Shipping Bill included the tonnage on a plan of internal measurement proposed by Mr. Morsom, which was but a slight improvement on the old plan; and it came into operation on the 1st of this month. His friend Mr. Scott Russell had just explained the mode in which it worked, that it increased the tonnage so considerably that the difference must cause additional cost to the public for the transport service. There were so many important questions before the Society that night, that at that very late hour he could not presume to occupy any more time, but he trusted that either the discussion might be continued at an adjourned meeting, or that some other opportunity would be afforded of stating the results of their experience on the subject which had been brought forward.

The Noble Chairman having proposed a vote of thanks to the author of the paper,

Mr. Atherton rose and said, that he had to thank his lordship and the meeting for the sentiments that had been expressed with reference to the cause which he had endeavoured to bring under notice that evening. He also begged to acknowledge the liberality of the Council in having received from himself, not previously a member of the Society, the paper which he had been permitted to read, thus giving the cause he advocated the advantage of that widely-spread publicity which this Society alone could command, for the proceedings of this meeting would engage the immediate attention of no less than 392 Institutions associated for purposes of public utility. And surely financial economy in the conveyance of goods by steam-ships, whether for the purposes of commerce or of war, was a subject which, perhaps, more than any other single object at the present time, vitally affected the prosperity and the national prowess of Britain, and the great interests dependent thereon. The exposition of steam-shipping anomalies which he had brought forward to substantiate his views, and the calculations which he had advanced, were such as might be expected to arouse the expression of discordant, but independent, and equally honest views on the part of others, as regards both theory and practice in naval construction. Suffice it to say, that he disclaimed being the discoverer or the ultra-advocate of any particular theory, even of that on which his calculations had been based. He had adopted that theory because he believed it to be the most generally received, the most easily understood, and practically the most useful of all the theories devised for the purpose referred to; but still he regarded it only as an approximation to Nature's hidden law; nevertheless he accepted it, and he submitted that we should adopt this theory till some other rule, more practically applicable for determining the mutual relation of displacement, power, and speed, should be discovered and established. All that he laid claim to was simply this—that, taking the received law of resistance to floating bodies as he found it already laid down by recognised authority, and which he believed to be trustworthy and closely approximate to fact, he deduced by its aid an *inquisitorial* system of steam-ship financial arithmetic, whereby the agents, managers, directors, in short, the trustees in charge of public or private shipping, might test the merits of their steam-ship stock, discriminate in regard to the skill and attention of their officers in charge, calculate the cost, and, consequently, the financial remuneration required in consideration of the services performed, and contract obligations in which they might engage, and in like manner, in their turn, be themselves held responsible for their stewardship by the proprietors for whom they acted. The introduction and establishment of such a system of inquisitorial arithmetic might be a formidable task, but the requirements of the public good originated the idea, and a conviction of being right in the prosecution of a useful object impelled him to persevere, and in this labour he hoped for the continued cooperation of the Society of Arts.

The Chairman said he had observed throughout the whole of this debate the apparent general assent of the meeting as to the necessity for some great change with regard to better defined calculations for tonnage, speed, and power to carry weight, than existed at the present day. He had observed in this meeting a very great disposition to accept the paper read by Mr. Atherton as, if not a perfect and entire mode of fixing and arranging the improved method of calculation, at all events an approximation so closely to a useful change in the present system of calculation, that it might be accepted as a great step towards improvement in that particular. He might be permitted to express his own conviction that the change was not only necessary, but he had been astonished at the mode of calculating tonnage which had existed so long with regard to steam ships. He was convinced that for the uses of steam ships, the means of calculation would so much enhance the value of steam, comparatively, by cheapening the purchase of the article, that any one would be able more conveniently to set at rest this question, so intricate and difficult, as the settlement of what description of cargo should be carried, and what speed should be obtained under the present mode of calculation. There were many points in the discussion to which he should have alluded had the time been more fitting for it, although he could have added nothing to the subject in a scientific point of view. Mr. Scott Russell in his remarks, had touched upon a subject which he (the chairman) thought was not altogether fitting for a Society like this to indulge in. He was satisfied the meeting would feel that they saw Mr. Scott Russell in the right place when they saw him sitting at that table and giving them instruction in ship-building and engineering. He believed there was no man, judging from the fame of his exploits, who was better placed in the position he holds; and he would say long might he continue to enjoy that wealth and high character which his great name had established for him, and which the constitution and the people of this country would not only give him the greatest amount of freedom to enjoy, but the people of this country would continue to respect his name and character in proportion to that degree of excellency and ability which he had at all times exhibited in his employment They also saw the right man in the right place in his friend on the left (Mr. Atherton). He was a gentleman whom Mr. Russell claimed as one of his own. He (the chairman) must on his part also claim him as one of his own, for he was a wrangler at Cambridge, over which county he (the chairman) had the honour to preside, and which was his native place. He was not only a wrangler at Cambridge, but he worked his way practically through the business of his profession, and he was now in the service of his country. There was also another man present—Mr. Chatfield—whom he had known all

his lifetime, and he was one example of those who ought to have risen more rapidly to the place he now holds, because as time and space bear a large proportion to the powers of the body, so if in early life he had had that position which he now holds, and which he was fitted for and ought to have had long before, his talents and merit would have been recognised in his appointment as surveyor of the navy. He would conclude his observations by repeating that it gave him great satisfaction to have had the honour of being in the chair that evening, for he looked forward with hope that from that meeting there might spring a change in the system of calculation —a change in the general system of mercantile management, which would very much tend to better the condition of that class of commerce and of that description of sea-going tonnage.

Mr. SCOTT RUSSELL proposed, and Mr. T. WINKWORTH seconded, a vote of thanks to the chairman, which was carried by acclamation.

The Noble CHAIRMAN briefly thanked the meeting, which was then adjourned.

The Secretary announced that the paper to be read on the evening of Wednesday next, the 23rd instant, was "On the Mutual Relations of Trade and Manufactures," by Professor Edward Solly, F.R.S. On this occasion there will be no discussion, as the Council believe the members will prefer to adjourn to the model room, to examine the collection of Animal Produce and Manufactures, being the first step towards the formation of a General Trade Museum.

USE OF LIME-WATER IN THE FORMATION OF BREAD.

To neutralise the deterioration which the gluten of flour undergoes by keeping, bakers add sulphate of copper or alum with the damaged flour. Professor Liebig, however, has conceived the idea of employing lime, in the state of solution, saturated without heat. After having kneaded the flour with water and lime, he adds the yeast, and leaves the dough to itself; the fermentation commences, and is developed as usual; and if we add the remainder of the flour to the fermented dough at the proper time, we obtain, after baking, an excellent, elastic, spongy bread, free from acid, of an agreeable taste, and which is preferred to all other bread after it has been eaten for some time. The proportions of flour and lime-water to be employed are in the ratio of 19 to 5. As the quantity of liquid is not sufficient for converting the flour into dough, it is completed with ordinary water. The quantity of lime contained in the bread is small—160 ounces of lime require more than 300 quarts of water for solution; the lime contained in the bread is scarcely as much as that contained in the seeds of leguminous plants. Professor Liebig remarks that "it may be regarded as a physiological truth, established by experiment, that corn flour is not a perfectly alimentary substance; administered alone, in the state of bread, it does not suffice for sustaining life. From all that we know, this insufficiency is owing to the want of lime, so necessary for the formation of the osseous system. The phosphoric acid likewise required is sufficiently represented in the corn, but lime is less abundant in it than in leguminous plants. This circumstance gives, perhaps, the key to many of the diseases which are observed among prisoners, as well as among children whose diet consists essentially of bread. * * * The yield of bread from flour kneaded with lime-water is more considerable. In my household, 19 pounds of flour, treated without lime-water, rarely give more than 24½ pounds of bread; kneaded with 5 quarts of lime-water, the same quantity of flour produces from 26 pounds 6 ounces to 26 pounds 10 ounces of well baked bread. Now as, according to Heeren, 19 pounds of flour furnish only 24 pounds 1½ ounces of bread, it may be admitted that the lime-water bread has undergone a real augmentation."—*Annalen der Chemie und Pharmacie*, and *Chemist*, March, 1855.

Home Correspondence.

ON PUBLIC WORKS FOR INDIA.

SIR,—I confess myself somewhat disappointed at the small amount of practical information elicited last evening at the adjourned meeting of the Society to discuss Colonel Cotton's paper, for, as was well observed, the object of the Society of Arts is the eliciting of facts, and not mere declamation. We desire, for instance, to know what has actually been done as regards public works in India, what is intended to be done, and what might be done. Colonel Cotton has supplied us with much valuable data, but he has not addressed himself to the whole question of improved public works, and has spoke mainly of works of water communication, and those confined chiefly to the Madras Presidency. It is not, as was remarked by one speaker, a mere question of controversy between advocates of railways and canals—of supporters or opponents of the policy of the Court of Directors. The subject rests upon a more wide and important basis, viewed in any of its varied aspects—socially, morally, commercially, or politically. The interests of Great Britain and the people of India are bound up with it. Improved communications are calculated to effect a great revolution in the agricultnre, in the commerce, and in the general habits of the natives. Already we have seen, in the traffic returns of the Bombay and East Indian Railways, how largely the natives have availed themselves of them. It was, I well remember, urged by opponents to their introduction that the poverty and prejudice of the natives would deter them from travel, and yet we find that, contrary to the experience of all other countries, the third-class passenger traffic is that which forms the main element of profit.

Instead of desultory discussion and vague generalisation on topics on which all were agreed, I should have liked to have heard some more complete details as to the road communications in particular districts, an abstract or *resumé* of the progresss of construction, cost, and returns of some of the Indian works—a list of the works completed and those in construction, or planned, and required. Surely, some of the old Indians present could have given us these interesting details, and corroborated or disputed Colonel Cotton's arguments, without throwing the whole of the labour and onus of this research and explanation on him. In the absence of this data I may be excused for making a few remarks, and adding the opinion of some of the leading Indian journals just received.

The difficulties in the navigation of the Godavery appear to be more formidable than Colonel Cotton has supposed. The latest report on this subject is furnished by the officer at present employed on the operations, which has recently been published in the *Madras Spectator*.

The editor of that journal, who is a great patron of the Godavery improvements, is so impartial as to confess that, after reading the report, Sir Henry Pottinger's doubts regarding the practicability of the undertaking no longer appear surprising. The cost of the necessary operations, it seems, will be very serious, and an application is to be made to the Government to sanction the outlay of double the amount already granted, half a lakh of rupees being found quite insufficient. The substance of the report is as follows:—

"In the whole distance over which the navigation will extend, 429 miles between Dowlaishwarum and Chandah, the total rise of the water surface is 491 feet; no figure to alarm one, we grant, if the ascent were distributed with anything like equality along the river's course, but a formidable amount of elevation has to be overcome, when occurring chiefly at a few points, which is the

case on the Godavery. For the space of 112 miles upwards from Dowlaishwarum the rise is gradual enough, but then a steep pitch is suddenly met with, between Cintral and Purnesalla, where rocks impede the stream for four miles together. There must here be considerable rapids. Between Purnesalla and Enchumpully, however, a further distance of 78 miles, no obstructions appear to exist, the ascent being easy until we reach the last named place, where the surface level is over 200 feet above that at Dowlaishwarum Anicut. But here again difficulties present themselves, in the shape of a mass of rocks extending over fourteen miles, and comprehending a rise of nearly thirty feet. This is immediately succeeded by an obstacle more serious still, at Punkina, where occurs an abrupt rise of above twenty feet, seemingly a downright fall of the river from that height. Surmounting that formidable interruption the course of the stream continues placid and our navigation easy till we arrive at Dewulamurre, 97 miles higher up, where the water level is 320.1½ above the Anicut, and here we once more meet with roaring rapids, bristling with rocks, for the continuous space of forty miles, and comprehending a rise of nearly 143 feet. That portion of the work of freeing the river channel will prove very arduous and expensive, but it is happily the last hindrance that the engineers are called on to encounter, the Godavery having then a quiet course as far as Chandah, 73 miles above Darnoor, where navigation, we suppose, will cease."

Such is the latest description of the difficulties which impede the navigation of the Godavery, and they have naturally induced even those who have no interest whatever in the question of River *versus* Rail Conveyance in this case, to question whether the Godavery is, after all, so well adapted for bringing down the cotton of the Berar Valley to Coringa, for exportation to England.

The *Friend of India*, one of the best informed of the Indian journals on modes of communication and general statistics, thus speaks on the transit by Bombay:—

"As at present advised, the Great Peninsular Railway Company, who have their line as far as Poona sanctioned, are likely to continue it from that point through Ahmednuggur, Dowlutabad, Boodwur, and Omrawutty to Nagpore. Such at least appears to be the present aspect of the direction it is likely to take. This would carry the rail into the very heart of the cotton districts in the valley of Berar, and afford facilities for the conveyance of the cotton wool to the western port of embarkation in twenty-four hours, and it will probably have the effect of securing the whole of the cotton traffic to that presidency. As regards the cost of transport, it would of course be premature to speak with any degree of precision at present. The charge for the conveyance of goods must necessarily depend on the cost of the line. Colonel Cotton assumes that the Bengal rail has been constructed at a charge of £20,000 a mile, but we think he will find the average expenditure as low as £10,000. The scale of rates for goods traffic on the colliery line just opened is now before us, and as it is not likely that the rail in the western presidency will be more expensive than our own, we may reasonably conclude that the tariff of charges will bear a very close resemblance. The tariff for the first class of goods at this presidency, which includes coal, coke, iron, lime, minerals, sand, and stone, is one eighth of a pie per maund per mile, which will be a trifle above a *farthing* a ton a mile. The charge for the second class, in which is included the article of cotton wool, is two-thirds of a pie a maund a mile, that is, a little in excess of *two farthings* a ton a mile. If screwed bales of cotton should be conveyed, therefore, from the cotton districts to Bombay, at our lowest rate—the distance being estimated at 400 miles—the charge would be at the rate of 37s. a ton, if at the next higher rate, at double that amount. But we think we shall not be very wide of the mark if we assume that when the Bombay rail reaches the centre of the cotton districts, and its returns depend in a great measure on cotton wool, the railway company will be no losers by conveying it from the place of its growth to the port at the rate of 50 shillings a ton, which will be at the rate of about a farthing and a quarter a pound. The question therefore, for consideration is, whether the cotton dealers will prefer sending their cotton down a difficult navigation, open for scarcely more than six months in the year, or by rail at all seasons, and at the rate for freight which, in either case, the article of cotton wool can well support. But, even if the expectations now held out of obtaining facilities for the conveyance of cotton by water to the port of Coringa, should not be realised, still, the opening up of the communication by the Godavery and the Wurda, generally, into populous and opulent districts, is a question of such paramount importance that it would be a dereliction of public duty to neglect it. We are not the partizans of either mode of communication. We care not whether the cotton is exported to England from Coringa or from Bombay. We intend to bestow our editorial commendation on that line, whether by steam or water, which shall deliver the cotton at the cheapest rate, and in the best condition, on board ship, to be conveyed to England. All that can be desired at present is, that the proposal to open the navigation of the Godavery shall not be allowed to interfere with the construction of the rail at Bombay, and that the construction of the rail on one side of the peninsula shall not damp the operations on the Godavery on the other side."

The construction of all works of communication, whether they be canals, roads, or railways, will necessarily lead to a much better knowledge of the geology of the country. Mineral discoveries will take place. For instance, there are three points on the southern frontiers of the Madras territories where coal is known to exist—one in Cuttack, on the Bahmanee river, one in the Hyderabad dominions at Kotah, on the Godavery, and one on the Nerbudda territory about Juddulpore. Another extensive deposit has recently been discovered near the Turcah hill, a situation intermediate between the before-named coal-basins.

A scientific survey should be made of all the Guzerat rivers, the Taptee, the Nerbudda, the Kini, the Dadur, the Myhe, the Karee, the Saburmuttee, the Badur, and the numerous small streams in the Gogo pergunnah, and then something would exist to work upon. But without systematic inquiry by competent officers irrigation in the Province of Madras will remain at a stand-still.

The demand for water may be estimated by the assiduity with which the natives resort to well irrigation. But then there comes a physical difficulty in the way, which all the parties seem to have overlooked—the influence of the tide is felt in the Nerbudda 60 or 70, and in the Taptee 40 or 50, miles from the sea, the gradient of the rivers never exceeding a foot a mile until they get beyond the Delta land altogether. The land itself again slopes more rapidly than the water, the banks increasing in elevation as we ascend the stream. Near Domus it is from twelve to fifteen feet above low-water; at Surat, it is thirty two; at the village of Veriow, four miles above Surat, it is thirty-six feet; and at Rustumbagh, twenty miles upward by the river, it is close on forty feet. The Nerbudda is still more untractable, the gradient of the stream being less, and that of its banks greater. At Broach it is about thirty feet, at Jenoore, twenty miles up the river, the northern bank is about eighty feet; the southern one slopes, so that there is some space washed by inundation, but in less than half a mile it attains an altitude of above thirty feet, and the whole region betwixt the Taptee and the Nerbudda is certainly fifty feet above the level of the streams. Mr. Mackay admitted this difficulty, but suggested that the canals should only be cut deep enough to be filled by the inundation, and that this should be reserved as a store for the remainder of the year, the canal becoming a gigantic tank. He forgot in this case that as the floods hardly ever exceed twenty-six feet the canals must be thirty feet deep before any water would enter them, that if they were made forty feet deep nearly the whole of their contents would be drawn off by evaporation, which in Guzerat amounts to from eight to ten feet.

It appears, from the *Madras Spectator*, that 28,773*l.* were expended on the repairs of tanks and water-courses in 1853-54, and that the estimate for the current year for the same purpose is 29,400*l.* The outlay of about 25,000*l.* had been sanctioned for making and improving the cotton roads of Tinnivelly and Ramnad, of which about 13,000*l.* had been already expended. The rise in the rates of labour, and the great scarcity of labourers, had rather retarded the progress.

The *Friend of India* states:—"For the last two years more especially, the Government of India has entered upon

schemes of public works to an extent altogether unprecedented. The public authorities have apparently passed at once from the extreme of parsimony to the extreme of prodigality. Thus, in the year 1853-54 the expenditure on public works amounted to £2,515,389, and the estimated expenditure for these works in 1854-55 amounts £2,974,300, which is thus distributed—For works in the Bengal and Agra Presidencies, in the Punjaub, and in Pegu, £2,058,703; at the Madras Presidency, £623,100; Bombay, £295,500. The sum devoted to roads and canals does not fall short of £88,000, and under this comprehensive sum are included the Ganges and the Baree Doab canals, the great bridges over the rivers in the lower section of the great trunk road from Delhi to Lahore, and from Lahore to Peshawur, which is now urged on with the utmost vigour; the important roads which are to connect the great towns in the Punjaub with each other, the great Decan road, the Bombay and Agra road, the Gya and Patna road, the Arracan road, and the roads which have been projected in Pegu."

There is no doubt of the value of artificial works of irrigation and navigation, of the construction of canals and the improvement of rivers, but who is to find the capital. If these works are to yield such large profits, why are they not undertaken by private enterprise. There is always abundance of capital in England, seeking safe and remunerative investment—something beyond the 3 or 3½ per cent. which the funded securities afford. I can, however, call to mind few Indian Commercial Companies, with the exception of banks, that have proved profitable investments. The Indian Steam Navigation Companies, Insurance Companies, and other Joint Stock Associations, have usually proved unfortunate speculations to the shareholders. It is only now, after 16 years' labour and a large expenditure, that the Assam Tea Company is beginning even to pay a dividend.

The great value, expediency, and importance of canals across the two principal isthmuses, Panama and Suez, have been repeatedly urged. Explorations havebeen made—engineering difficulties asserted to be mere trifles by those who surveyed, and the prospects of remuneration for the outlay of capital reported to be considerable. But when the matter came to be closely investigated by practical men, it was found impossible to carry them out, and railways, although so much decried, are, therefore, supplying the means of transit, perhaps not so thoroughly effective, but, nevertheless, forming useful mediums of communications.

What the Court of Directors seem anxious to effect is, to draw British capital to India, to encourage public enterprise, to give facilities to Joint Stock Associations, and these will assuredly find out practicable and profitable undertakings, and the best channels for investment. Thus we find an Oriental Gas Company lighting up the city of Calcutta. The Western India Canal and Irrigation Company, with a proposed capital of 500,000*l.*, with such men as Mr. F. C. Brown, Mr. Frith, Mr. Kennedy, Colonel Grant, and Dr. Buist, identified with it, extending its operations into Scinde. These gentlemen consider it "the interest of England to look to India as a field for permanent investment, and for India to look to England as the source whence her means of local improvement and commercial enterprise are to be derived."

The projectors further state, after various calculations, that "in the North West Provinces, such canals produce 28 per cent. clear profit, those in the Punjaub are estimated to produce 26 per cent., and that those in the Madras Presidency, where the water appears to be charged at a rate much more commensurate with its real value to the cultivator, the profits are from 70 to 140 per cent. on the total outlay;" and yet, with such brilliant prospects before them these gentlemen stand out for their pound of flesh—they would make assurance double sure—for as a proof of their want of confidence in their own estimates, they are "applying to the Court of Directors for a 5 per cent. guarantee, and unless this guarantee is obtained, the company will not go on."

During the discussion on this subject before our Society very heavy and grave charges of indifference and of gross neglect in the great matter of public works have been preferred against the East India Company, and not a word in reply has been uttered by any of the many gentlemen connected with India present, who must have known something of the matter. Colonel Sykes was the only speaker who met the charges, by a statement of figures—which was most unaccountably omitted in the *Journal* in its proper place.*

I have no desire to become the apologist for the Court of Directors. As a journalist I have had frequent occasions to speak of their shortcomings and political mismanagement, but in this matter of public works I think the charges advanced against them are much too sweeping and too general to be successfully maintained, and could, I believe, be fairly met and replied to. They may have pooh-poohed or snubbed Colonel Cotton—as he informs us—they may have thrown cold water on his magnificent canal and irrigation schemes—they may have expended less money than they ought to have done on the works of the Madras Presidency—but it does not necessarily follow that they have been totally regardless of their own interests, and the general interests of the various presidencies in a total neglect of public works. Some allowance should be made for the nature of a vast country split up into a variety of acquired states, having separate feelings and separate interests—where governors die off or are changed before they have time to become even partially acquainted with the wants of the district, or the best system to be pursued to supply these wants. Political disturbances, again, in various quarters, and new acquisitions of territory, have from time to time distracted attention from that steady progress which can only be made in times of prosperity and tranquillity.

But have the East India Company done nothing to improve India? Have they done nothing to give a character to the Indian navy? Have not their steamers been the pioneers of commerce and improvement on all the great rivers of the east? Have not steam and electricity even been carried into the very wilds of Burmah, literally verifying the native proverb supposed to be expressive of the perpetuity of the kingdom—"When a ship can ascend the Irawaddi against the wind and tide, without sails or oars, then shall the Burmese empire fall."

During the whole course of the discussion not a word in respect of the important department of public works recently organised for India was mooted, save the brief allusion to the loan of two millions and three quarters sterling raising for that purpose, made by Colonel Cotton in the postcript to his paper.

And yet, sir, a twelvemonth ago, this great subject of public works appears to have been occupying the attention of the Indian Government; and the able and practical Governor General, who is so thoroughly conversant with these subjects, has given his mind fully to the subject, and seems to have required no prompting from Colonel Cotton. The various minutes from the governors of the presidencies, with the accompanying comments by the Court of Directors, are published in full in the last Indian journals, and certainly deserve a passing notice.

This new public works loan is apportioned to the several presidencies and lieutenant-governorships as follows:—

Bengal	1,250,000
Agra and the Punjaub	700,000
Bombay	500,000
Madras	300,000
	£1,750,000

* This omission was supplied in the succeeding Number.—Ed.

The *Friend of India* remarks that the large scale on which public works have been commenced since the impulse given by the discussions on the India Bill has rendered it necessary for the government to induct on the funds of the community for the means of carrying them forward. With a deficit of a million sterling in the public finances it was obviously impossible to continue these material improvements upon the basis now adopted without such subsidiary aid. Two proposed works will absorb nearly 20 lakhs of rupees (£20,000). These are the great Gya and Patna road, now under the management of Lieutenant Peile, the estimate of which is 13 lakhs of rupees, and the stone bridge across the Barakar, for which Major Knyvitt has long been collecting materials, and which he has instructions, we believe, to commence without delay, at a cost of six lakhs of rupees more.

A comptroller of public works for India has been appointed, with three assistants, one of whom is to preside over irrigation, one over roads and canals, and one over buildings and other works. The whole system is thus at once to be reduced to order, and public works throughout India will become a great separate branch of internal administration, conducted upon settled principles, and with the advantage of the best scientific and professional advice. Does this look like neglect and indifference ?

The newly-appointed Secretary for Public Works in India is to have 3,600*l.* a year, and an appointment for five years, with an assistant secretary. The new establishment is to be made fully adequate to the duties it is to discharge, and for this purpose the Engineer corps has been augmented by one battalion. Young officers of the engineer corps are to receive a longer course of civil engineering before they leave England. A complete system of instruction is to be provided at Madras for every class belonging to the department of public works, Europeans, East Indians, and natives, whether artificers, foremen, overseers, surveyors, or civil engineers. The government are also about to establish a class of assistant civil engineers for employment on the public works in the provinces, open to all qualified, whether European or native, the salaries being fixed at from four to six hundred rupees a month, whilst the highest species of engineering accomplishments do not seem to be insisted on.

The control of this department of Public Works has been transferred to Colonel Waddington as chief engineer, who is instructed to prepare annually, for submission with the estimates, the following series of sketch maps, besides the standard one :—

1st. A map of all existing roads, showing the *actual condition* of each at the date of preparation, which date is to be inserted in the map.

2nd. A map such as No. 1, but containing, also, in distinctive colours, any additional roads *sanctioned* at the same date.

3rd. A map containing all that is shown in No. 2, and in addition (shown distinctively) those lines of road which it is proposed to submit for the sanction of the government of India with the annual estimates to which this whole series of maps will be a continuous illustration.

The Court agree with Mr. Grant, that a geographical division of duty is the best arrangement. The works of each great division would thus be brought under one view; and every properly qualified engineer should be equally competent in every branch of his profession. All the branches of it are, indeed, dependent on each other; canals of navigation may also be canals of irrigation; they must have lateral embankments, transverse bunds, bridges where they intersect roads, and possibly aqueducts. So with all other public works; and those of one class, if they are not simultaneously considered, may either be inconveniently interfered with, or not properly connected with those of another.

The general principles relative to the vast public benefit to be derived from the maintenance and extension of works of irrigation, and from facilitating and improving the means of internal communication throughout the country, are fully recognized by the Government, and are to be vigorously acted upon.

For the purposes of giving effect to these principles, a requisite portion of such surplus revenue as may accrue is to be applied to the construction of public works; and if there shall be no surplus revenue, such public works are nevertheless to be carried on by means of loans, to be raised by the Government of India for the purpose. The Directors remark upon this :—

"We have in our despatch of the 5th of July last directed the application of the requisite sums for the completion of public works of importance in all our presidencies, from the balances now in the treasuries of India (which arise principally from sums contributed to the open loans), and we have therefore already recognized the principle involved in this proposal. In case of its being necessary hereafter to raise any specific loan for this purpose, our previous sanction must be given."

An able writer in the first number of a new and well-written Indian periodical, the *Bombay Quarterly Review*, in noticing the late Mr. Mackay's book, after alluding to the facilities which were given him in the prosecution of his inquiries by the Indian government, the assistance and the information afforded him by the local authorities, access to all public records, &c., points out the common errors which he and all other generalisers falls into :—

"Not a thought is bestowed on the difficulties of the position of the East India Company—its debt—its limited revenue—the few European servants it can afford to keep up for civil employ in the districts, or the state in which the country was when it came into the possession of the British. But all Mr. Mackay's efforts are directed to show, and to convince his mercantile constituents, that the Indian government ought to double its expenditure and give up one half its revenue; a government already in debt, and with little or no surplus revenue as it is ! How this is to be accomplished, and the public treasuries are to answer the call of those who attend on the first of the month for their salaries, we are left to divine. It is worse than puerile for one who is drawing up articles of impeachment against the East India Company, to reason in this fashion. Any person can easily point out what India wants, and can, with irresistible logic, make out that the country has been scandalously neglected—if the pecuniary part of the matter may be left entirely out of consideration."

With the perfect freedom of the press existing in India for the last twenty years—where neither stamp, censorship, nor shackle of any kind prevails—every want, every grievance, is speedily made known, discussed, and commented upon. To the influence of the press must be attributed the great improvement in the recent charter granted to the East India Company, and which will tend greatly to the benefit of the people of India.

An intelligent native gentleman, in a lecture recently delivered at Bombay, pointed out some of the advantages which had been conferred in India. The admission of natives into the covenanted services of the East India Company—the improvement and extension of courts of justice—the increased impetus to the cause of education, and the establishment of universities in the different presidencies—the formation of native associations in Bengal, Madras and Bombay—the exposition of the Baroda Khutput—the improvement of the cultivators in the interior of the country—the introduction of railways and electric telegraphs in India—the abolition of the shop and stall tax at Bombay—the publication and opening of government records—the commission for inquiring into torture cases—the abolition of the horrid and inhuman practices of infanticide and suttee—the abolition of the slave trade in Travancore and Malabar—the effectual prevention of human sacrifices in Gondwana—the suppression of thuggee which prevailed from the Himalayas to Cape Comorin—the introduction of a uniform system of postage—the introduction of female education,—all these, and the formation of many societies for the social and moral amelioration of the people of India, owe their origin in a great degree to the unfettered

advocacy of the press, and certainly the East India Company has been the instruments of carrying them out.

However much cause therefore there may be for blame owing to apathy and slow progress, the field is not all barren. The Court of Directors may want, as all governments occasionally do, the propelling voice of public opinion and popular discussion, like the policeman's lanthorn and staff, requesting them to "move on." And it is therefore from this cause that scientific inquiry and free publicity may do good, by stimulating to greater exertions for the advancement of the general welfare of India.

Apologising for these crude remarks,
I am, sir,
Your obedient servant,
P. L. SIMMONDS.

5, Barge-yard, May 8th, 1855.

To Correspondents.

ERRATA.—In No. 127, 1st column, 13th line, for "making, read "many;" 2nd column, 3rd line, for "one" read "an;" 3rd column, 18th line, for "representation" read "representative;" 3rd column, 21st line, for "our change" read "overcharge."

*** The Secretary begs to state, that owing to the length to which the proceedings of the weekly meetings have lately run, he has been reluctantly obliged to omit numerous letters and articles, including a paper by Mr. Andrew Henderson, "On the Past and Present History of Life Boats;" letters by Mr. Hugo Reid, on "Reformatory Schools;" by Mr. S. A. Good, on "Decimal Coinage;" by Mr. S. Sidney, on "Mr. Chadwick on Indian Irrigation;" and by Colonel Cotton on "Public Works for India."

MEETINGS FOR THE ENSUING WEEK.

MON. Architects, 8.
Chemical, 8.
Statistical, 8. Mr. H. R. Lack, "On the Mining Resources of France." Rev. R. Everest, "On the Distribution of the Emigrants from Europe over the surface of the United States,"

TUES. Royal Inst. 3. Dr. Tyndall, "On Voltaic Electricity."
Meteorological, 7. Anniversary.
Civil Engineers, 8. Mr. G. Herbert, "On Stationary Floating Batteries;" and Mr. G. Baillie, "On Volute Springs for the Safety Valves of Locomotive Boilers."
Med. and Chirurg., 8½.
Zoological, 9.

WED. Society of Arts, 8. Prof. Edward Solly, "On the Mutual Relations of Trade and Manufactures."
Microscopical, 8.
Royal Soc. Literature, 8½.

THURS. Linnæan, 1 p.m. Anniversary.
Royal Inst. 3. Mr. G. Scharf. jun., "On Christian Art."
Numismatic. 7.
Antiquaries, 8.
Royal, 8½.

FRI. Ethnological, 3. Anniversary.
Philological, 8. Anniversary.
Royal Inst., 8½. Dr. Hofman, "On Ammonia."

SAT. Royal Inst., 3. Dr. Du Bois Reymond, "On Electro-Physiology."
Royal Botanic, 3¾.
Medical, 8.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

Delivered on 7th May, 1855.

Par. No.
140 (6). Civil Service Estimates—Class 6.
190. Metropolis Local Management—Return.
105. Bills—Customs Duties (amended).
106. Bills—Religious Worship.
107. Bills—Weights and Measures.
108. Bills—Intestacy (Scotland) (as amended by the Committee, and on Consideration of Bill, as amended).
Poor Law Board—7th Annual Report.
The Crimea and Scutari (State of the Hospitals of the British Army)—Report.

Delivered on 8th May, 1855.

215. Staff Officers (Crimea)—Return.
220. Medical Department (Navy)—Treasury Minute.

Delivered on 9th May, 1855.

201. Spirit of Wine—Copies of reports.
221. Assaults on Women and Children (Dublin)—Return.
224. Railway and Canal Bills Committee—4th Report.
99. Bills—Piers and Harbours—(Scotland.)
104. Bills—Infants Marriage.
109. Bills—Registration of Births, &c.—(Scotland)—(amended.)
111. Bills—Sewers—(House Drainage.)
Subdivision of Parishes—3rd Report of Commissioners.

Delivered on 10th of May, 1855.

204. Army (Crimea)—Return.
223. Army—Return.
211. Troops in "Seringapatam"—General Sutherland's Report.
218. Army before "Sebastopol"—3rd Report from Committee.
Eastern Papers (Negotiation at Vienna)—Part 13.
Turnpike Trusts—4th Report by the Secretary of State.

Delivered on 11th of May, 1855.

219. Poor Relief (Ireland)—Return.
225. Home-made Spirits—Account.
110. Bills—Burial Grounds (Scotland) (amended).
112. Bills—Nuisances Removal, &c. (Amended by the Select Committee).
Public General Act—Cap. 18.

Delivered on 12th and 14th of May, 1855.

216. Public Offices (Subjects of Examination)—Returns.
222. Merchant Seamen's Fund—Account.
226. Carnatic Debts—Returns.
227. Polling Papers—Return.
229. Tithe Commutation—Returns.
230. Railway and Canal Bills Committee—5th Report.
233. Naval Prize, Bounty, &c.—Account.
208. Savings Banks—Return.
117. Bills—National Gallery, &c. (Dublin).
118. Bills—Spirit, &c., Duties (Excise) (Amended).
119. Bills—Sewers (House Drainage) (Amended).
113. Bills—Jurisdiction of the Stannary Court Amendment.
114. Bills—Lunatic Asylums (Ireland) (Advances) (Amended).
116. Bills—Alterations in Pleadings.
115. Bills—Victoria Government.

Delivered on 15th May, 1855.

Education—Minutes of the Committee of Council.

Delivered on 16th May, 1855.

234. Legacy, &c., Duties—Return.
235. Militia—Return.
121. Bill—Rating of Mines.
Turnpike Trusts—5th Report by the Secretary of State.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, May 11th*, 1855.]

Dated 15th February, 1855.

343. B. Gower, Stratford—Ordnance and projectiles.

Dated 30th March, 1855.

707. W. Crozier, Sunderland—Extinction of fire.

Dated 14th April, 1855.

825. J. Armstrong, Normanton Station, and J. Livingston, Leeds—Permanent way.
827. J. A. Herbert, Guilford—Conical propellers.
829. T. Kennedy, Kilmarnock—Propellers.

Dated 16th April, 1855.

831. P. A. le Comte de Fontaine Moreau, 4, South-street, Finsbury—Felted tissue. (A communication.)
833. R. Husband, Manchester—Hat plushes.
835. E. H. Bentall, Heybridge—Harrows.
837. G. Beard, Birmingham—Label and stamp setter.

Dated 17th April, 1855.

839. A. W. Callen, Camberwell, J. West, Guernsey, and G. W. Lewis, Bristol, U.S.—Tents.
841. P. A. Devy, 10, Old Jewry-chambers—Swing looking-glasses. (A communication.)
843. G. F. Wilson, Vauxhall, and W. De la Rue, Bunhill-row—Fluids for lamps.
845. E. E. Allen, 376, Strand—Steam engines.
847. R. C. Clapham, Ardrossan—Salts of baryta and artificial iron pyrites, &c.

Dated 18th April, 1855.

849. H. Woodhouse, Stafford—Railway crossings.
851. L. Dameron, Paris—Carriages.
853. J. Kay, Bonhill, N.B.—Printing textile fabrics.
855. J. H. Johnson, 47, Lincoln's-inn-fields—Moulding and casting fusible or plastic materials, and covering articles with same.—(A communication.)
857. W. Madeley and T. Hanlon, Manchester—Looms.
859. F. Russell, 13, Cumberland-market, Regent's-park—Hanging window sashes.
861. W. V. Edwards, Swindon—Portable boiler and cooking apparatus.

Dated 19th April, 1855.
863. T. Lees, Birmingham—Metallic pens.
867. W. Bishop, Old Fish-street-hill—Ornamenting writing papers.
871. P. Lear, Boston, U.S.—Horizontal submerged propellers.
873. W. Savory, Gloucester—Crushing grain and cutting chaff.
875. J. H. Johnson, 47, Lincoln's-inn-fields—Articles of hard india-rubber or gutta-percha, or compounds, &c. (A communication.)
Dated 20th April, 1855.
877. J. C. Pearce, Bowling Iron Works, Bradford—Pipe joints.
879. W. Ryder, Bolton-le-Moors—Slubbing and roving machinery.
881. C. L. V. Maurice, St. Etienne—Carbonizing steel.
883. J. Lord, Rochdale—Temples for power looms.
885. H. Allen, New York—Valves.
887. W. L. Bennett, Wolston—Seed drills.
889. J. Drury, Paddock, near Huddersfield—Preventing explosion of steam boilers.
Dated 21st April, 1855.
891. W. Gerhardi, Manchester—Preventing straps lapping round shafts.
895. W. P. Sharp and W. Weild, Manchester—Spun or thrown silk thread.
897. J. H. Johnson, 47, Lincoln's-inn-fields—Spinning machinery. (A communication.)
899. W. A. Edwards, 87, Brook-street, Lambeth—Separating metals from metallic substances.
901. S. Walsh and J. Brierley, Halifax—Belt, band, or strap fastener.
Dated 23rd April, 1855.
903. J. Whitworth, Manchester—Ordnance fire-arms and projectiles.
905. J. Orr and J. Templeton, Glasgow—Figured fabrics.
907. A. V. Newton, 66, Chancery-lane—Separating substances of different specific gravity. (A communication.)
Dated 24th April, 1855.
910. J. Taylor, King-street, Westminster—Propelling vessels.
911. W. W. Richards, Birmingham—Revolving fire-arms.
912. J. Horsfall, Manchester—Mitreing sashes.
913. J. and G. Hunter, Leysmill, Forfar—Stone-cutting machinery.
914. F. Mc Kenna, Salford—Power looms.
915. F. J. Utting, Wisbeach—Land rollers and clod crushers.
916. M. A. Muir, Glasgow—Railway chairs.
917. C. P. Smyth, Edinburgh—Astronomical and geodetical instruments.
918. C. Jordan, Newport—Discharging cannon.
Dated 25th April, 1855.
921. L. A. Avisse, Paris—Lubricating revolving shafts.
923. J. Wallace, jun., Glasgow—Cleansing textile fabrics.
924. M. Mason, Dukinfield—Metallic sole-tips and heels.
925. J. J. Victory, Henrietta-street—Marking out curved lines upon wood and stone, and boring and sawing wood.
926. J. Black, Hampstead-road—Axles, shafts, and bearings.
927. J. Hunter, Liverpool—Distillation of turpentine, &c. (A communication.)
928. A. E. L. Bellford, 32, Essex-street—Planing screw nuts and bars. (A communication.)
929. A. E. L. Bellford, 32, Essex-street—Gas regulator. (A communication.)
930. A. E. L. Bellford, 32, Essex-street—Seamless garments, &c., of felt. (A communication.)
931. A. E. L. Bellford, 32, Essex-street—Weighing machine. (A communication.)
932. J. B. Wilkin, Helston—Stamping and dressing ores.
933. A. E. L. Bellford, 32, Essex-street—Chaff-cutting machine. (A communication.)
934. A. E. L. Bellford, 32, Essex-street—Lock for sliding doors. (A communication.)
936. S. Draper, Lenton, Nottingham—Stopping railway trains.
937. J. Jeffreys, Kingston-hill—Raising, diffusing, or injecting fluids.
938. E. Frankland, Manchester—Treatment of alums and products therefrom.
939. G. A. Huddart, Brynkir, Carnarvon—Motive power.
940. J. Peabody, Old Broad-street—Haymaking machine. (A communication.)
941. J. Silvester, Smethwick—Spring balances to steam valves.
942. G. A. Huddart, Brynkin, Carnarvon—Motive power.
Dated 26th April, 1855.
943. J. Elce and J. Bond, Manchester—Protecting revolving shafts and mill work.
944. P. A. le Comte de Fontaine Moreau, 4, South-street, Finsbury—Preventing escape of fluids. (A communication.)
945. A. E. L. Bellford, 32, Essex-street—Slide valves. (A communication.)
946. W. Shears, Bankside, Southwark—Gunpowder magazines.
947. T. H. Burley, Ohio—Making dovetails.
Dated 27th April, 1855.
948. Capt. R. P. Coignet, Paris—Rendering tissues waterproof.
949. P. A. le Comte de Fontaine Moreau, Paris—New material for bearings. (A communication.)
950. A. Crosskill, Beverley—Turning cut grasses or hay.
951. T. Page, Middle Scotland-yard—Ordnance.
953. J. C. G. Massiquot, Paris—Lithographic presses and inking apparatus.
955. H. Collett, 12, Grosvenor-street, Islington—Pumps.
956. E. Myers and J. W. Potter, Rotherham—Stoves.
957. R. Clark, Strand, and J. T. Stroud, Birmingham—Lighting.
Dated 28th April, 1855.
958. T. and J. Knowles, Manchester—Steps and bolsters for spinning machinery.
959. D. Warren, Exmouth—Motive power.
960. F. J. W. Packman, M.D., Puckeridge, Herts—Projectiles.
961. A. V. Newton, 66, Chancery-lane—File-cutting machinery. (A communication.)
962. W. E. Carrett, Leeds—Motive-power engines.
963. J. Marsh, 13, Store-street—Pianofortes.
Dated 30th April, 1855.
965. E. Acres, Waterford—Dessicating and cooling air.
967. W. Johnson, 47, Lincoln's-inn-fields—Gas regulator. (A communication.)
969. H. Francis, 456, West Strand—Boots and shoes.

WEEKLY LIST OF PATENTS SEALED.

Sealed May 11th, 1855.
2412. Samuel Pearson, Woolwich—Improvement in the manufacture of gun barrels, pipes, and tubes.
2424. George Henry Ingall, Throgmorton-street—Improved method of communication between passengers and guards, &c., for the prevention of loss of life and accidents on railways.
2425. Peter Knowles and Edward Kirby, Bolton-le-Moors—Improvements in machinery for opening, cleaning, and preparing cotton and other fibrous materials.
2429. Samuel Henton, Lambeth—Improved saddle.
2431. John Platt, Oldham—Improvements in machinery or apparatus for making bricks.
2433. William Low, Lloft-Wen, near Wrexham—Improvements in ventilating mines.
2437. James Higgins and Thomas Schofield Whitworth, Salford—Improvements in apparatus for moulding for casting shot, shells, and other articles.
2444. William Coulson, Fetter-lane—Improvements in machinery for morticing, tenoning, and boring.
2449. Edouard Belmer, 8, Macclesfield-street, City-road—A new manufacture of apparatus for warming rooms and workshops.
2502. John Clarke, Leicester—Improvements in the manufacture of looped fabrics.
2520. William Taylor, Howwood by Paisley—Improvements in steam boiler and other furnaces.
2526. Edward Briggs and William Souter, Castleton Mills, near Rochdale—Improvements in machinery and apparatus for gassing yarn and thread.
2528. Julian Bernard, Club chambers, Regent-street—Improvements in the manufacture of boots, shoes, or other protectors for the feet, and in the machinery or apparatus connected therewith.
2614. William Chippindale, Leeming-bar, near Bedale, and Leonard Robert Sedgwick, Crakehall, near Bedale—Improvements in steam boilers.
144. Robert Martin, High-street, Tottenham, and Jacob Hyams, Union-street, Bishopsgate—Improvements in goloshes or overshoes.
231. Henry Davis Pochin, Salford—Improvements in the treatment of certain compounds of alumina, and the application of the same in printing, dyeing, tawing, paper making, and such like purposes.
374. Lieut. Frederick Blacket Edward Beaumont, R.E., Upper Woodball, Barnsley—Improvements in fire-arms called revolvers.
406. Benjamin Looker, junior, Kingston-upon-Thames—Improvements in ventilating stables and other buildings.
608. Edmund Reynolds Tayerman, 79, Pall-mall—Improvements in portfolios for holding papers.
Sealed May 15th, 1855.
2415. Jean Marie Chevron and Charles Victor Frederic de Roulet, Paris—Improvements in machinery for manufacturing textile fabrics.
2513. John Moore Hydé, Bristol—Improvements in iron steam ships and in boilers and machinery for propelling the same.
2568. Joseph Phelps, Croydon—Improvements in apparatus for damping postage and other stamps, labels, and like articles.
2618. Auguste Edouard Loradoux Bellford, 16, Castle-street, Holborn—Improvements in sewing machines.
2700. Louis Joseph Frederic Marguerritte, Paris—Improvements in the manufacture of sulphuric acid.

WEEKLY LIST OF DESIGNS FOR ARTICLES OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietors' Name.	Address.
3716	May 12.	Fastenings for Stays, and other Articles of Dress	George Waide Reynolds	Birmingham.
3717	„ 15	Self-acting Trap for Catching Rats and Mice	Colin Pullinger	Selsey, near Chichester.